Engineering Library

DEC 17 1935


# The Engineer

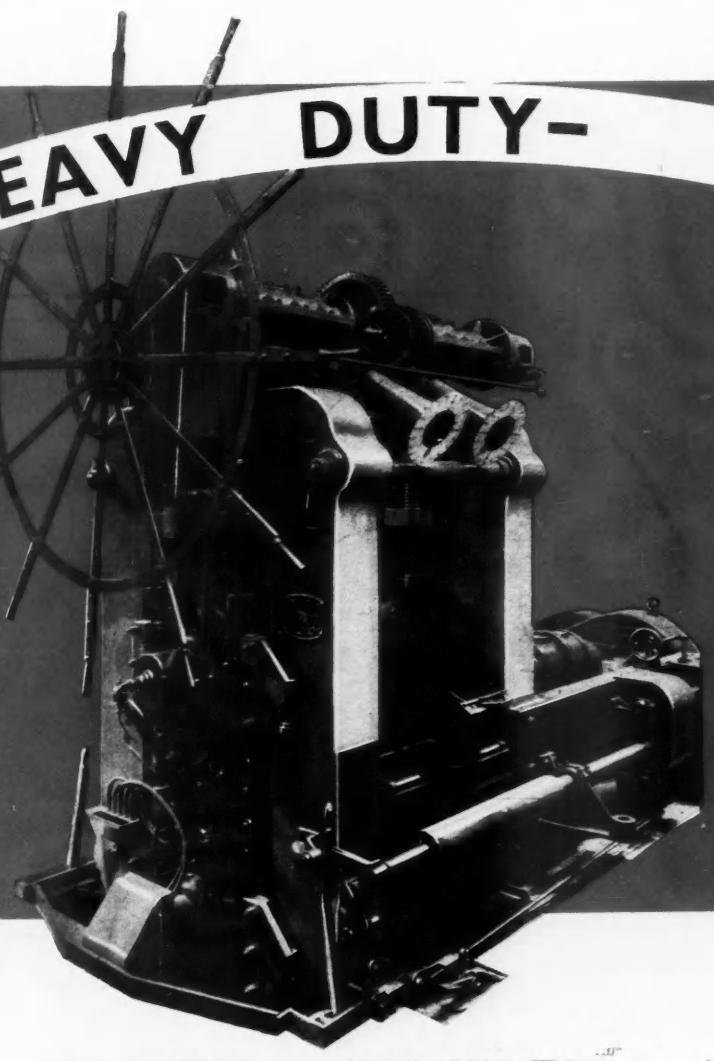
ESTABLISHED 1856. REGISTERED AS A NEWSPAPER.

VOL. CLX.—No. 4169] 28, ESSEX ST., LONDON, W.C. 2. [DECEMBER 6, 1935



TRADE MARK : TIMKEN.

FOR HEAVY DUTY—



*The photograph shows a 4-high cold strip mill supplied to Messrs. Eduardo K. L. Earle, Bilbao, Spain, for a cold rolling non-ferrous strip and sheet mill.*

MADE IN ENGLAND

## TIMKEN - EQUIPPED mills

**ARE REGULARLY PRODUCING**

84″ WIDE STEEL SHEETS, hot rolled down to ·050″ for deep drawing purposes.

PANEL STEEL SHEETS for automobile body work.

36″ WIDE STAINLESS STEEL strip, cold rolled down to ·010″.

DURALUMIN SHEETS to the lightest gauge.

ALUMINIUM STRIP for all commercial purposes.

BRASS, COPPER and other non-ferrous strips, cold rolled to a tolerance of ·00007″.

Timken tapered roller bearings are used in mills of the largest and heaviest description on account of their capacity to withstand the most arduous operating conditions and are being specified to an increasing extent for modern mills of all types.

They completely eliminate troubles common to the ordinary plain bearing, they effect considerable power savings and give greater accuracy of product.

The largest Hot and Cold Mills in the world are Timken-equipped—

**Specify Timken for Heavy Duty and Accuracy.**

BRITISH TIMKEN LTD., CHESTON ROAD, ASTON, BIRMINGHAM.
Telephone: East 1321 (6 lines). Telegrams: Britimken, Phone, Birmingham.

TIMKEN TAPERED ROLLER BEARINGS

PROTECT STEEL WORK,
under-frames of rail trucks, bridges, coal chutes, water troughs and towers, etc., with
TEXACO BITUMINOUS COMPOSITIONS and SOLUTIONS

PROTECT steel pipes by lining and coating with
TEXACO BITUMEN

THERE IS A
TEXACO
BITUMEN FOR EVERY PURPOSE

Enquiries Invited.

THE TEXAS OIL COMPANY LTD., Asphalt Dept.
Thames House, Millbank, London, S.W.1. Tel : Vic. 9903-7

PROGRESS
by determination to produce only the best.

350 B.H.P. Brotherhood High-Speed Diesel Engine coupled to a dynamo.

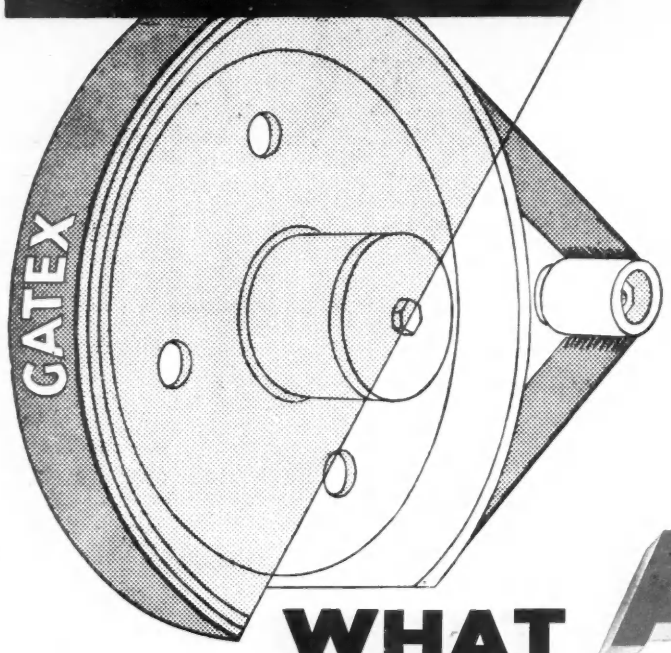
SPECIALISTS IN COMPRESSORS, STEAM ENGINES, TURBINES, PUMPS, REFRIGERATING MACHINERY, ETC.

This is a typical seven-cylinder 350 B.H.P. Brotherhood-Ricardo Oil engine. Every detail of construction is critically supervised, no effort is spared to produce a compact, easy starting, smooth-running and efficient unit. For all powers between 40 and 540 B.H.P.

*Write for particulars.*

PETER BROTHERHOOD LTD
PETERBOROUGH

*It's amazing...*




GATEX POSSESSES A REMARKABLE CO-EFFICIENT OF FRICTION COMBINED WITH A HIGH DEGREE OF FLEXIBILITY AND CAN BE WOVEN ENDLESS

¶ For High Speed and High Ratio drives Angus "Gatex" Belting offers exceptional efficiency. With a co-efficient of friction approximately six times as great as Balata and twice as great as Leather, "Gatex" grips strongly even if run with more "slack" than is usually possible. Two benefits follow from this—the life of the belt on the pulley is increased and the friction (and wear) on shaft bearings is reduced. "Gatex" is the latest advancement in Transmission Belting.

WHAT ANGUS GATEX BELTING WILL DO!

FREE! *Make full use of the advisory service offered by our technical staff or alternatively we shall be pleased to send a belting engineer to your works to give first-hand advice on your problems. Literature and price lists upon request.*

WRITE TO DEPT. T.E.

GEORGE ANGUS & CO. LTD., NEWCASTLE-UPON-TYNE

BRANCHES: London, Liverpool, Leeds, Manchester, Birmingham, Cardiff, Belfast and Glasgow

# A Seven-Day Journal

## A Conference by Wireless.

LONG-DISTANCE wireless telephony has ceased to create wonder and to claim much attention. The possibility of being able to speak to telephone subscribers in places thousands of miles away is now treated more or less as a matter of course. But a wireless conference held on Friday last at the London office of International Combustion, Ltd., should arouse new enthusiasm, for it is said to have been the most ambitious scheme the British Post Office has been called upon to organise. Its principal objects were to establish personal contact with the company's overseas staffs and clients, and to demonstrate as forcibly as possible to prospective customers in the overseas Dominions the company's interest in their problems. A report on the company's activities read at Aldwych House, London, by Mr. Geo. C. Usher, the managing director, was transmitted to Wellington, in New Zealand, and Sydney, Melbourne, Adelaide, and Perth, in Australia. At the same time, it was sent to Bombay by the Anglo-Indian radio-telephone service, and relayed by land line to Calcutta. By means of the Anglo-South African radio-telephone service it was simultaneously transmitted to Cape Town, and relayed by land line to Johannesburg and Bulawayo. Buenos Aires and New York were also served *viâ* the direct radio-telephone service to South America. Post Office cables were used during the conference for transmitting the report to Paris and to the company's works at Derby. When Mr. Usher had finished speaking reports were received in London from the company's office in Bombay and Johannesburg and from those at Perth and Sydney in Australia. Great credit is due to the British Post Office for the arrangements which made the conference possible, especially as, in addition to the wireless channels, thousands of miles of land lines were involved.

## A New London Subway.

ON Tuesday, December 3rd, the Lord Mayor of London, Sir Percy Vincent, opened the new pedestrian subway which has recently been constructed below the junction of King William-street, Cannon-street, and Gracechurch-street. The Minister of Transport, Mr. Hore-Belisha, and Lord Ashfield, Chairman of the London Passenger Transport Board, took part in the opening ceremony. The subway has been built at a total cost of about £45,000, and is designed to enable pedestrians to avoid street crossings which are always congested with traffic, while it also gives access to the Monument Underground Station. It is immediately above the Underground Railway and has been constructed by the London Passenger Transport Board as agent for the City Corporation; the Board also contributed to its cost. The subways are tiled and are well lighted, and their use should tend to facilitate the handling of traffic and to reduce the number of street accidents. Speaking at a luncheon given at the Fishmongers' Hall by the Streets Committee, after the opening ceremony, Mr. Hore-Belisha said that the City of London, although one of the most crowded, was one of the safest spots in the world. Because of its special conditions, it had always shown a greater readiness than other authorities to provide subways. The City had a splendid record with regard to the small number of street accidents in its area, but he expressed the hope that this new subway under a junction over which 31,000 vehicles passed per day would diminish even the present small total.

## Centralising the Sale of Steel.

THE most interesting development in the iron and steel situation is the announcement that the long-expected central selling organisation for the British industry is at last about to take shape. A company, of which the two original directors are the Earl of Dudley and Mr. Ian F. L. Elliot, has been registered with a nominal capital. It is understood that its title will be the British Iron and Steel Corporation, Ltd., and that Mr. Elliot, who at present is assistant managing director of the British (Guest, Keen and Baldwins) Iron and Steel Company, Ltd., will be chairman of the new concern. The formation of this organisation was foreshadowed in the draft constitution of the British Iron and Steel Federation when that body replaced the old National Federation of Iron and Steel Manufacturers. The intention is to establish an organisation through which all the steel makers, as well as the re-rollers, will sell their steel for export, and which will purchase all the imports of iron and steel and resell the material to consumers, but it will not sell British steel in the home market. According to report, membership of the new company will be voluntary, and much will depend upon the way in which it is received by the industry as a whole. It is expected that a good indication of this will be given at a meeting of the British steel makers which is being held this week at Harrogate. The new organisation will absorb the British Steel Export Association, which, since the end of 1929, has handled a proportion of the British steel makers' overseas business, particularly with Canada. Part of its duties will be to supervise the imports of Continental steel, and it is known that the Federation would very much like to arrange for all Cartel imports to be purchased and distributed by the new company. The Continental makers, however, are opposed to this course and desire to conduct their sales through their existing organisations.

## The Late Professor J. D. Cormack.

MANY of our readers will learn with regret of the sudden death of Professor John Dewar Cormack, Regius Professor of Civil Engineering and Mechanics at Glasgow University, which occurred at his home, 11, Park-terrace, Glasgow, on Saturday last. Professor Cormack was attending his duties at the University up till the early part of the week, and succumbed to an attack of pneumonia. He was only sixty-five years of age, and since his appointment twenty-two years ago he had worthily upheld the great traditions of his Chair. A son of the late Mr. Alexander Cormack, rector of the Dumbarton Academy, he had a distinguished career at the University of Glasgow, from which he graduated with distinction in engineering. After taking his degree, he assisted the late Professor Barr for some time, and was then appointed Lecturer in Electrical Engineering. Earlier, he spent some time in Leeds as Lecturer in Electrical Technology at Yorkshire College. In 1901 he was appointed Professor of Mechanical Engineering at University College, London, and in 1913 returned to Glasgow to succeed Professor Barr as Regius Professor of Civil Engineering and Mechanics. During the war he served as Chief Contracts Officer, Military Aeronautics, in 1915, Assistant Director of Aircraft Equipment in 1916, and Assistant Controller of the Aeronautical Supply Department in 1917. From 1917 to 1918 he was a member of the British Mission to America. Besides being a Doctor of Science, he was Honorary Brigadier-General and also Honorary Group Captain, R.A.F., and in 1917 he was made C.M.G., whilst the C.B.E. was conferred upon him in 1919. He was a Chevalier of the Legion of Honour and a member of the Institution of Mechanical Engineers, the Institution of Electrical Engineers, and a Fellow of the Royal Aeronautical Society. He took an active interest in the engineering life and activities of Glasgow, and in 1933 was elected President of the Institution of Engineers and Shipbuilders in Scotland.

## Water Pollution Research.

ON Monday, December 2nd, the annual report of the Water Pollution Research Board was issued by the Department of Scientific and Industrial Research. In it attention is drawn to the importance of accurate information on the water resources of the country and their variation with different conditions of weather. Four main groups of investigations are being carried out under the supervision of the Board. They deal with water for public supply, with sewage, with trade waste waters, and with the problems of river pollution. The report summarises the principal results obtained during the last few years in an investigation of the base-exchange process of water softening employed by several water supply undertakings. Fresh experiments have shown that base-exchange materials can remove all traces of metals, such as lead, copper, zinc, and tin, from water. An outstanding discovery resulting from the Board's work is that certain synthetic resins possess marked base-exchange properties, greater in some instances than the base-exchange values of existing commercial materials. Instances of pollution of rivers and streams have resulted from the discharge of effluents from dairies and milk products factories, to such an extent that the development of means of dealing with the problem has become urgent. Numerous experiments have been carried out on the conditions affecting the rate of deposition of mud and clay from suspension, including the effects of adding sewage to the suspensions.

## Refrigeration in the South African Fruit Trade.

IMPORTANT orders for fruit precooling plant have been placed by the South African Railways and Harbours Board with J. and E. Hall, Ltd., of Dartford, Kent. A new precooling station is to be built on the new extension to the Cape Town Harbour at "C" berth New Basin, with a final capacity of 3750 cubic tons. In addition, cold storage accommodation for holding already precooled fruit pending shipment will be provided at No. 4 shed, South Arm, first floor, to the extent of 1000 tons, and also at Knuckle Berth, New Basin. At Port Elizabeth a new building with a capacity of 4000 cubic tons has been decided upon for precooling both citrus and deciduous fruits, and this plant will also be constructed by J. and E. Hall, Ltd., which firm is at present completing a similar, but smaller, installation at East London. Some idea of the magnitude of these undertakings can be obtained from the figures for electric motor powers. Taking the motors for refrigerating plant only, the aggregate power at Cape Town will amount to nearly 2500 b.h.p.; at Port Elizabeth, about 1700 b.h.p., and at East London about 520 b.h.p. The ammonia compressors are to be of the totally enclosed type with forced lubrication, variable control duty, arranged for direct coupling to motors. The condensers will be of the vertical shell and tube type, for sea water circulation. The coolers include a brine-spraying system and a special plant is installed for concentrating the brine. The most economical conditions for operation of the ammonia circuit will be ensured by the installation of dry compression apparatus. The completion of these plants, in conjunction with eleven new ships having a total insulated capacity of 3,750,000 cubic feet and about 6100 h.p. of Hall's latest refrigerating machinery, should put South Africa for many years in a leading position to handle effectively the export of the many varieties of South African fruit on a very large scale.

## L.M.S. Programme for 1936.

THE London, Midland and Scottish Railway Company announces that it has now completed its works and rolling stock programme for 1936, involving an expenditure of £8,500,000 on major replacements and improvements. The programme, which is quite distinct from that for the works to be constructed under the proposed Government guaranteed loan, includes the provision of 133 locomotives, 111 locomotive boilers, 687 carriages, 9485 wagons, 900 containers, and three steamers. In addition, the company will renew 600 miles of permanent way. The 133 locomotives will be built in the company's shops, and forty-eight will be similar in type to the three-cylinder 4–6–0 "Jubilee" class tender locomotives. The scheme also includes seventy 2–6–4 passenger tank engines, and fifteen 2–8–0 express freight tender locomotives. About one million pounds is to be spent in providing 687 passenger coaches of the latest design. The new freight wagons will range from the 12-ton standard to 30-ton bogie bolster rail and timber trucks, while the 900 new containers will be designed to meet the requirements of particular industries. The programme also provides for over 300 motor vehicles. The expenditure on permanent way renewals will amount to 1½ million pounds, and will include the renewal of 600 miles of track. During the year three new vessels will be built for the L.M.S. fleet; a cargo steamer for the Heysham-Belfast route, a passenger vessel for the Clyde, and a dredger for Fleetwood Harbour. Provision has also been made for a number of modernisation schemes at docks and hotels, in addition to the new hotel at Leeds.

## The Fuel Luncheon Club.

THE Fuel Luncheon Club, referred to in our Journal note of November 15th, was inaugurated by Sir John Cadman, its first President, on Wednesday, November 27th, at the Connaught Rooms. In the course of his speech, Sir John said that the Club would have achieved its principal aim if, merely by its sociability, it encouraged greater and more frequent contact between the technical men of the different branches of the fuel industries. Such contacts, if once established, might widen until they embraced all branches and knit them, maybe, into a structural unity or at least into a network of co-ordinated organisations. There was, Sir John said, at the present time, too little contact among our fuel industries; each tended, perhaps, to keep to itself, to pursue its own aims, benefiting from its own discourses and to ignore the advance of others. No section regarded itself as part of an organisation having a single aim, nor did any section co-operate with others for the benefit of all. Some such effort to emphasise the interdependence of our coal, gas, electricity, and oil industries was really needed, and no way of beginning, he thought, could be better than the frequent contact among technical men which the meetings of the Club would provide. Particulars of the Club may be obtained from Mr. R. T. Rees, at the Institute of Fuel, 53, Victoria-street, London, S.W.1.

## A Light Castings Combine.

IT is credibly reported that a project which has been under contemplation for some time, for the foundation of a combine in the light castings industry, has now been completed. We are given to understand that eleven ironfounding firms, with a capital of considerably over £1,000,000, have agreed to merge their interests and will found a combine which may be regarded as complementary to Allied Founders, Ltd. The larger number of these companies have their works in Scotland, and among those named in connection with the negotiations are the Camelon Iron Company, Ltd., the Grangemouth Iron Company, Ltd., and Watson, Gow and Co., Ltd., in the Falkirk area, while other foundries in the West of Scotland are said to include the Lion Foundry Company, Ltd., and Cameron and Robertson, of Kirkintilloch.

# Mechanical Flow Meters.

By Dr. F. V. A. E. ENGEL and R. J. WEY.

No. II.

(*Continued from page 560, November 29th.*)

### Design of Shaped Limbs and Floats.

FOR the design of differential manometers with shaped limbs or floats, *i.e.*, for U-tube manometers as well as floating bells, a knowledge of the equations determining the shape is essential. An analysis of these equations will also give a more precise idea of the non-linear section at the beginning of the scale, which was dealt with briefly in one of the previous paragraphs. The derivation and final form of these equations is very similar for the three different types of flow meters under consideration. The equations of the floating bell have been previously investigated by R. Moissonnier (*l.c.*) and one of the authors[15] has published the relationships of the U-tube manometer with the specially shaped limb.

To enable a comparison to be made of the important features of design of the three classes of flow meters, therefore, the equation of the shaped float as illustrated in Fig. 7 *ante* will be considered.

As the rate of flow through the primary device, *i.e.*, a Venturi tube or measuring orifice, is proportional to the square root of the differential head, the travel of the float must also be proportional to the square root of the differential head. This is more conveniently expressed as follows :—

$$h = C\,t^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The constant C in this equation is a meter constant and since a certain maximum differential head is related to a maximum travel of the float in the instrument the constant C can be obtained from

$$H = C\,T^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The mercury level in the high-pressure and low-pressure limbs of the differential manometer will alter as if there were no float present, provided that the float is perfectly free to move.

Assume an increase in differential head causing a displacement of $d\,s_1$ and $d\,s_2$ in the two limbs—see Fig. 11—the mercury level will drop from $M_1$ to $N_1$

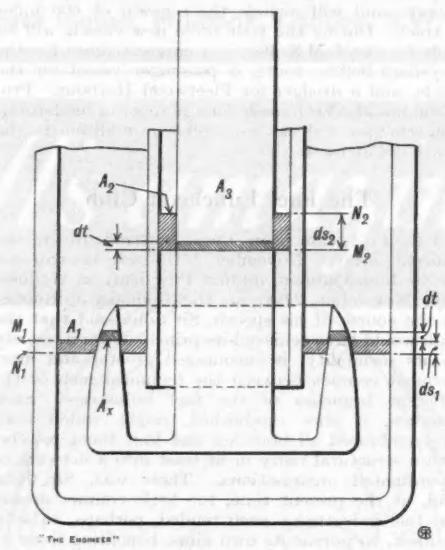



FIG. 11—DIAGRAM RELATING TO SHAPED FLOAT METER

and rise from $M_2$ to $N_2$. Neglecting the displacement of the float, this results in the following equation :—

$$(A_1 - A_x)\,d\,s_1 = (A_2 - A_3)\,d\,s_2 \quad . \quad . \quad . \quad (4)$$

Actually the float being free to rise until equilibrium is restored, the amount of mercury displaced is smaller than given in the above equation. Subtracting the total emergent volume of the float due to its own travel, which is equal to the area of the float $(A_3 + A_x)$ times the amount of travel $d\,t$, from the right-hand side of the equation, the following is obtained :—

$$(A_1 - A_x)\,d\,s_1 - (A_3 + A_x)\,d\,t = (A_2 - A_3)\,d\,s_2 \quad . \quad (5)$$

Rearranging equation (5),

$$A_1\,d\,s_1 - A_x\,(d\,s_1 + d\,t) = A_2\,d\,s_2 - A_3\,(d\,s_2 - d\,t) \quad . \quad (6)$$

It will be seen that adding equation (11)—the proof of which will be given later—to the last equation results in the following :—

$$A_1\,d\,s_1 = A_2\,d\,s_2 \quad . \quad . \quad . \quad . \quad . \quad (7)$$

which shows that the mercury level in both limbs will move as if no float were present.

Further, the differential head is equal to the drop in mercury level in the one limb plus the rise of mercury in the other limb, giving

$$d\,h = d\,s_1 + d\,s_2 \quad . \quad . \quad . \quad . \quad . \quad (8)$$

By eliminating $d\,s_1$ or $d\,s_2$ respectively we obtain the following relations for the increments in the fall and rise of mercury level :—

$$d\,s_1 = \frac{A_2}{A_1 + A_2}\,d\,h \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$d\,s_2 = \frac{A_1}{A_1 + A_2}\,d\,h \quad . \quad . \quad . \quad . \quad . \quad (10)$$

As the float must always be in equilibrium, the changes in the upthrust acting on the float in both the high-pressure and low-pressure limbs have to be equal—see Fig. 11—which results in

$$A_x\,(d\,t + d\,s_1) = A_3\,(d\,s_2 - d\,t). \quad . \quad (11)$$

In order to express the variable area of the shaped float as a function of the differential head and the travel of the float, $d\,s_1$ and $d\,s_2$ are eliminated in equation (11) from equations (9) and (10), resulting in

$$d\,t\,(A_x + A_3) = d\,h\left[\frac{A_1\,A_3}{A_1 + A_2} - \frac{A_x\,A_2}{A_1 + A_2}\right] \quad . \quad (12)$$

which may be rewritten as

$$\frac{d\,h}{d\,t} = \frac{(A_x + A_3)\,(A_1 + A_2)}{A_1\,A_3 - A_x\,A_2} \quad . \quad . \quad . \quad (13)$$

Differentiating equation (2) with respect to the travel $t$, a new expression for $\frac{d\,h}{d\,t}$ is obtained,

$$\frac{d\,h}{d\,t} = 2\,\frac{H}{T^2}\,t \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Substituting (14) in equation (13), the variable area $A_x$ is obtained as a function of the various dimensions and the meter constant C.

$$A_x = A_3 \cdot \frac{2\,\frac{H}{T^2}A_1 t - (A_1 + A_2)}{2\,\frac{H}{T^2}\,A_2 t + (A_1 + A_2)} \quad . \quad . \quad . \quad (15)$$

The section $A_x$ occurs at a distance $y$ from the zero level, assuming the float stationary at zero, and $y$ is

$$y = s_1 + t = \frac{A_2}{A_1 + A_2} \cdot \frac{H}{T^2}\,t^2 + t \quad . \quad . \quad (16)$$

The shaped part of the float can be calculated by the use of equations (15) and (16), but it may be more convenient to express the variable area $A_x$ as a function of $y$ instead of expressing it as a function of the travel $t$.

In order to obtain an equation in which $A_x$ is a function of $y$, $t$ has to be eliminated in equation (15) from equation (16) to obtain equation (17).

$$A_x = \frac{A_3}{A_2}\left[A_1 - \frac{A_1 + A_2}{\sqrt{4\,\frac{A_2}{A_1 + A_2} \cdot \frac{H}{T^2} \cdot y + 1}}\right] \quad . \quad (17)$$

Equations (15) and (16), or equation (17), are the characteristic equations of the differential manometer with the special shape of float.

From equation (15) it is evident that $A_x$, the area of the shaped float, becomes zero if the term in the numerator becomes zero. Thus there exists a certain minimum theoretical travel before the shaped part of the float comes into operation, which means that for this part the movement of the float will not follow the linear law required, but will be proportional to the differential head, and therefore proportional to the square of the rate of flow. Equating the term in the numerator of (15) to zero, we obtain the following equation for the minimum theoretical travel

$$t_{th} = \frac{1}{2}\,\frac{T^2}{H} \cdot \frac{A_1 + A_2}{A_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

This equation is merely a function of the different dimensions of the meter. The minimum travel for which linear movement of the float cannot be obtained is related to a certain differential head which is given in equation (19)

$$h_{min} = \frac{1}{4}\,\frac{T^2}{H} \cdot \frac{(A_1 + A_2)^2}{A_1^2} \quad . \quad . \quad . \quad . \quad . \quad (19)$$

Eliminating $h$ in the equations (9) and (10), equations (20) and (21) are obtained.

$$s_{1min} = \frac{1}{4}\,\frac{T^2}{H} \cdot \frac{A_2}{A_1^2}\,(A_1 + A_2) \quad . \quad . \quad . \quad . \quad (20)$$

$$s_{2min} = \frac{1}{4}\,\frac{T^2}{H} \cdot \frac{A_1 + A_2}{A_1} \quad . \quad . \quad . \quad . \quad . \quad (21)$$

which gives the change of the mercury levels in both the limbs of the differential manometer for the point at which the linear relation between the movement of the float and the rate of flow commences.

The shaped part of the float only controls its movement for a travel exceeding the theoretical value, as given by equation (18). The actual travel of the float for the initial range therefore cannot be given by equation (18), as the movement of the float is only controlled by the rise of the mercury level in the low-pressure limb. This means that the actual travel has to be equal to the rise in the low-pressure limb, which is given by equation (21). The actual travel of the float corresponds only to half the amount as given by equation (18), which is evident from equations (18) and (21). The following relation for the actual travel $t_a$ is thus

$$t_a = s_{2min} = \frac{1}{2}\,t_{th} \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

To illustrate the different relations regarding the theoretical zero level of the mercury, reference is made to Fig. 12. The distance of the top of the shaped part of the float from the zero level of the mercury is equal to the sum of the drop of the mercury level $s_{1min}$ plus the rise $t_a$ of the float, giving equation (23) :

$$y_a = s_{1min} + t_a = s_{1min} + s_{2min} = h_{min} \quad . \quad . \quad (23)$$

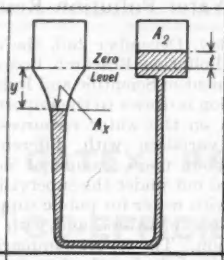
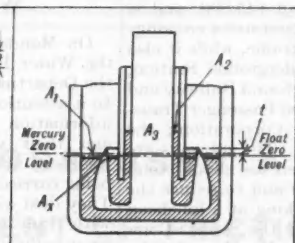
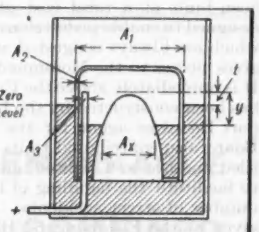
which, in the zero position, is equal to the value of the differential head at which the linear movement of the float commences.

For the purpose of calculating and designing the shaped part of the float, it is convenient to transfer the zero point of the ordinate $y$ to the point at which the area of the shaped float $A_x$ becomes zero, and this is obtained by subtracting $y_{th}$ from the expression for $y$ as given by equation (16). The relation of $y_{th}$ is as follows :—

$$y_{th} = t_{th} + s_{1min} = h_{min} + s_{2min} \quad . \quad . \quad . \quad . \quad (24)$$

From the practical point of view, it is important to limit the non-linear part of the instrument to the smallest amount possible. The percentage of the non-linear part is given by the ratio of the square roots of the minimum differential head over the maximum differential head, as given by equations

TABLE I.

| TYPE OF METER. |   |   |   |
|---|---|---|---|
| 1. Area $A_x$ of the Shaped Section as a Function of the Float Travel. | $A_x = \frac{A_2}{2\,\frac{H}{T^2}\,t - 1}$ | $A_x = A_3 \cdot \frac{2\,\frac{H}{T^2}\,tA_1 - (A_1 + A_2)}{2\,\frac{H}{T^2}\,tA_2 + (A_1 + A_2)}$ | $A_x = (A_1 - A_3) \cdot \frac{2\,\frac{H}{T^2}\,t}{2\,\frac{H}{T^2}\,t + 1} - A_2$ |
| 2. Ordinate $y$ at Which the Area has the Value $A_x$ as Given in 1. | $y = \frac{H}{T^2}\,t^2 - t$ | $y = \frac{A_2}{A_1 + A_2} \cdot \frac{H}{T^2}\,t^2 + t$ | $y = \frac{H}{T^2}\,t^2 + t$ |
| 3. Area $A_x$ of the Shaped Section as a Function of the Ordinate $y$. | $A_x = \frac{A_2}{\sqrt{4\,\frac{H}{T^2}\,y + 1}}$ | $A_x = \frac{A_3}{A_2}\left[A_1 - \frac{A_1 + A_2}{\sqrt{4\,\frac{A_2}{A_1 + A_2} \cdot \frac{H}{T^2} \cdot y + 1}}\right]$ | $A_x = (A_1 - A_3)\left[1 - \frac{1}{\sqrt{4\,\frac{H}{T^2}\,y + 1}}\right] - A_2$ |
| 4. Limitations of Equations Given Above for $y = 0$ And $A_x = 0$ Respectively. | $y = 0,\ A_x = A_2$ | $A_x = 0,\ y = \frac{1}{4}\,\frac{T^2}{H} \cdot \frac{(A_1 + A_2)\,(2A_1 + A_2)}{A_1^2}$ | $A_x = 0,\ y = \frac{1}{4}\,\frac{T^2}{H} \cdot \frac{2A_2\,(A_1 - A_2) - A_2^2}{(A_1 - A_2 - A_3)^2}$ |
| 5. Non-Linear Part at Beginning of the Scale in Percentage of the Maximum of Scale. | $100\,\frac{T}{H}$ | $50\,\frac{T}{H} \cdot \frac{A_1 + A_2}{A_1}$ | $50\,\frac{T}{H} \cdot \frac{1}{\frac{A_1 - A_3}{A_2} - 1}$ |

"The Engineer"

[15] J. Velds en F. Engel, "Electrisch Aanwijzende Venturimeters," *De Ingenieur*, 43, 1928, pages E27–E33.

(18) and (19), resulting in the following relation :—

$$100\sqrt{\frac{h_{min}}{H}} = 100\,\frac{t_{th}}{T} = 50\,\frac{T}{H}\,\frac{A_1+A_2}{A_1} \quad . \quad . \quad (25)$$

From equation (25) it can be seen that the linear part of the scale of the mechanical flow meter increases with a decrease in the maximum travel, with an increase in the maximum differential head, and a decrease in the area $A_2$ in comparison with the cross-sectional area $A_1$ of the meter body. There are, however, certain limitations in the dimensions. The area $A_2$ has to be sufficiently large to include the cylindrical part of the float with the area $A_3$, as the performance of the instrument, particularly its zero reading, depends on that area. Further, for a given maximum differential head, which has to be chosen with respect to the primary devices in the conduit, *e.g.*, a Venturi or an orifice plate, and also with respect to the maximum rate of flow, the travel of the float will have a certain minimum value, which in practice should not be less than about 1in.

To facilitate comparison, the more important relationships for the three types of differential manometers which have been dealt with previously are given in Table I.

The first sections of Table I give the equations which determine the shape of the limb or floats respectively, whilst the fourth and fifth sections deal with some limitations of the above-mentioned equations. These limitations refer to the non-linear start of the scale of the three different types of meters. It is of interest to note the similarity of the various terms in the relationships for the different types of meters.

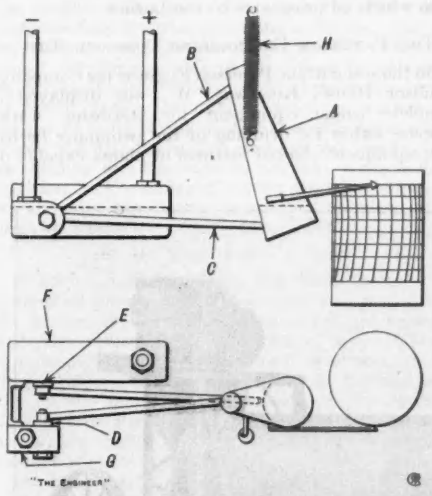



FIG. 13—GEHRE HYDROSTATIC BALANCE METER

In the case of the U-tube manometer, the equations for the shape of the limb are limited by the ordinate $y$ becoming zero. At this point the variable area $A_x$ of the high-pressure limb becomes equal to the area $A_3$ of the cylindrical low-pressure limb. This does not occur at zero differential head, and at this point the linear law gives place to the square-root relationship of float travel and flow. From the first equation can be found the travel $t$ at this point, which is given by $2\frac{H}{T^2}\,t-1$ becoming unity. Hence, $\frac{t}{T}=\frac{T}{H}$, or, expressing this as a percentage of full scale,

$$100\frac{T}{H}.$$

It might be thought possible to extend the range of the linear scale by using negative values of $y$, for which $A_x$ becomes greater than $A_3$, but since $y$ actually is the drop in level of the filling liquid in the high-pressure limb, *i.e.*, the differential head minus the float travel in the low-pressure limb, this would mean that the travel would exceed the differential head, which is clearly impossible. Therefore, the values given in the table are the limits, and give the relationship from which the percentage of full scale of the initial non-linear portion can be determined.

The various equations for the U-tube manometer with the specially shaped float have been dealt with at length in the previous paragraphs and are reproduced to enable a comparison to be made with the relationships of both the other designs. Between these equations and those of the floating bell, which are analysed in the last column of Table I, there is an evident similarity in the different terms. In both cases the limitations of the general equations are given by the area of the float or displacer becoming zero. The non-linear part of the shaped float meter will always exceed

$$50\,\frac{T}{H}\text{ per cent.},$$

whilst for the floating bell it will be normally much less than

$$50\,\frac{T}{H}\text{ per cent.},$$

the actual value for the same ratio of T/H being only dependent on the various dimensions of the design.

Considering two high-pressure flow meters of the U-tube type, both designed for the same differential head H, it is evident that the meter with the shaped float will be preferable. The travel of the shaped float can be 30 per cent. more than that of the U-tube with the shaped limb for a value of $A_2$ equal to 40 per cent. of $A_1$, provided that the linear scale in both types commences at the same percentage of the scale.

Another example may prove the utility of Table I for selecting the correct type of meter. In the case of gas measurement the differential head available is comparatively small—say, only 2in. W.G.—and the travel of the float may be chosen also as 2in., to obtain sufficient working force. The ratio T/H is unity for the above-mentioned values, which makes it impossible to employ a U-tube meter, as no linearly divided scale could be obtained, whilst the floating bell meter can be easily designed to have a linear scale with respect to the rate of flow extending at least over 90 per cent. of the scale. These points, however, are not all the considerations in the selection of the correct type of meter, a problem which will be dealt with at the conclusion of the section on flow meters.

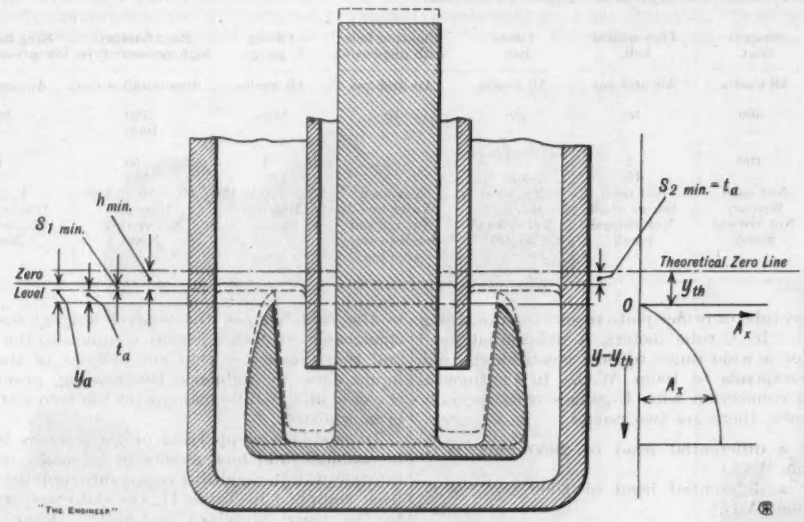



FIG. 12—ILLUSTRATING INITIAL RANGE OF SHAPED FLOAT METER

## NOTATION.

$h$ = differential head.
$h_{min.}$ = differential head for initial non-linear range—equation (19).
H = maximum differential head of the meter.
$t$ = travel of the float.
$t_a$ = actual travel of float in the initial range—equation (22).
$t_{th}$ = minimum theoretical travel—equation (18).
T = maximum travel of the float.
C = meter constant—equation (3).
$A_1$ = cross-sectional area of the high-pressure limb.
$A_2$ = cross-sectional area of the low-pressure limb.
$A_3$ = cross-sectional area of the cylindrical part of the float.
$A_x$ = cross-sectional area of the shaped part of the float.
$s_1$ = drop in mercury level in low-pressure limb.
$s_{1min.}$ = drop in mercury level for the initial range—equation (20).
$s_2$ = rise in mercury level in high-pressure limb.
$s_{2min.}$ = rise in mercury level for the initial range—equation (21).
$y$ = distance of section $A_x$ from theoretical zero line—equation (16).
$y_a$ = distance of the top of shaped part of the float from the mercury zero level—equation (23).
$y_{th}$ = distance of the top of the shaped part of the float from the (theoretical) zero line—equation (24).

$y$, $y_a$, and $y_{th}$ are determined with the float stationary at zero—see Fig. 12.

### HYDROSTATIC BALANCES.

In the hydrostatic balance type of flow meter the weight of filling liquid displaced in the differential manometer is balanced against a force provided by gravity or by the extension of a spring.

There are several types of this class of meter and the following three may be distinguished :—

(1) Balances in which only one limb of the differential manometer is movable ;
(2) Balances in which both limbs are movable and
(3) Ring balances.

One of the first designs of an industrial flow meter was the Gehre meter,[16] which was especially used in the field of steam measurement. Fig. 13 illustrates the principle of this meter. It consists of a specially shaped conical tube A, which is fitted at the top and bottom with pipes B and C, which, in turn, are pivoted at D and E and connected up to two reservoirs F and G. The conical tube can move round these pivoted points and is supported by a spring H. These pivoting points should introduce as little reaction as possible on the movable system and should also be pressure-tight, two requirements which are not easily fulfilled together. The reservoir is filled with mercury.

The principle of operation is as follows :—With a rise in differential pressure mercury flows from the reservoir F into the conical tube, the resultant increase of weight causing the spring to extend until balance is restored.

Another meter of the same type,[17] in which only one limb of the differential manometer is movable, is shown in Fig. 14. The movable limb is a container A, which is supported by a float B, the outside contour of this container being such as to ensure a linear movement with respect to the rate of flow.

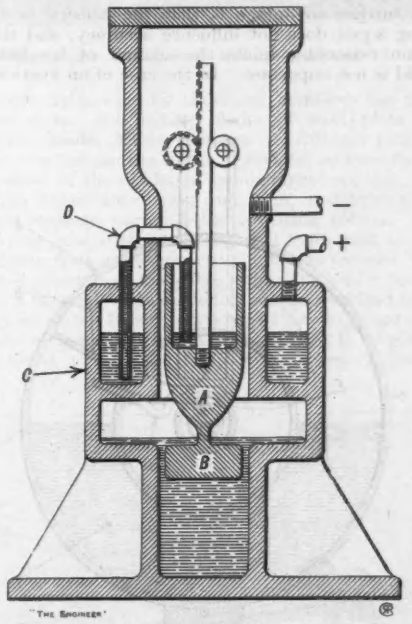



FIG. 14—HYDROSTATIC BALANCE WITH SHAPED DISPLACER

The container is connected to the stationary limb C of the manometer by a syphon tube D. This arrangement overcomes the difficulty arising with the Gehre meter due to the pivoting of the pipes connecting the conical tube to the stationary reservoirs.

A balance with both limbs of the differential manometer movable is shown in Fig. 1 *ante*. This is the first design of a mechanical flow meter used in connection with Venturi tubes and was originated by Clemens Herschel in 1888 (*l.c.*) and has since been considerably improved in design. Due to the displacement of the mercury columns F and G, when a differential pressure is applied, the centre of gravity is shifted and the U-tube will be deflected until a corresponding counterforce from the two control weights H and I is produced. In the more recent designs the control force is obtained by a cam which presses against a metal ribbon supporting the control weight. The advantage of this arrangement is that a linear relationship between the deflection and the rate of flow is possible, which was not obtained in

[16] Max Gehre, "Improvements in Means for Measuring the Flow of Steam or Other Fluids," British Patent Specification, No. 24,196, 1907.

[17] British Patent Specification, No. 164,144, 1920.

the original design by Clemens Herschel. Interchangeable control weights can be supplied, thus enabling full-scale deflection of the meter for various differential heads to be obtained.

Fig. 15 illustrates the ring balance meter, which is in common use, especially in the field of gas flow measurement. This meter consists of a ring-shaped container A of either circular or rectangular cross section. The partition B above the sealing liquid C separates the high and low-pressure sections, which are connected by flexible tubes D and E with the primary device. The whole body of the ring balance is supported by a knife-edge F resting on a bearing surface G. There is a control weight H attached to the container A.

Strictly speaking, the symmetrical ring balance is not a hydrostatic balance in the same sense as the types previously dealt with. The filling medium acts only as a seal and the force which operates the ring balance is obtained by the differential pressure acting on the partition B. The displacement of the filling liquid does not produce the measuring torque as in the tilting U-gauge shown in Fig. 1 *ante*. The ring balance is deflected from its zero position until the torque produced by the differential pressure is counterbalanced by the displacement of the control weight H. The maximum angle of deflection lies normally between 40 deg. and 60 deg., and the control weight is interchangeable with others of different size, giving a range of maximum differential pressures for full-scale deflection.

A further advantage is that the density of the filling liquid does not influence accuracy, and that within reasonable limits the amount of the filling liquid is not important. In the case of an overload,

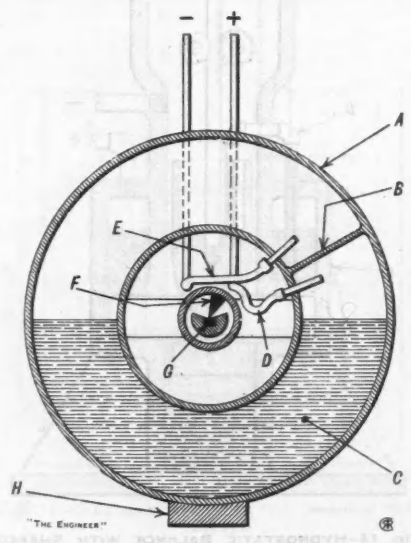



FIG. 15—RING BALANCE

the excessive pressure will equalise by breaking through the sealing liquid and therefore no special overload device is necesssary.

The design as shown in Fig. 15 does not give a linear relationship between its deflection and the rate of flow. This is normally obtained by a cam attached to the container A and a follower driving the main spindle of the indicating, recording, and integrating mechanism.

In another method[18] of obtaining a linear scale, the control weight is suspended by means of a flexible metal strip which passes over a cam mounted on the container. Thus by shaping the cam the control torque can be varied over the entire range to obtain a linear scale.

### RANGE OF APPLICATION OF TYPES OF MECHANICAL FLUID FLOW METERS.

The conditions of the medium to be measured, its density, static pressure and velocity, and also the type of primary device—for example, Venturi tube, orifice plate, or Pitot tube—have a deciding influence on the selection of range and type of the flow meter. In the case of a Venturi tube or orifice plate, the differential head *inter alia* is a function of the velocity and the area of the throat or opening of the primary device, which is normally dimensioned to have an area ratio of the opening to the pipe of between 0·1 and 0·5. In general, the larger ratios are preferred, resulting in smaller losses of static pressure. Further, the head loss is proportional to the differential head which should therefore be as small as possible, but, on the other hand, high enough to obtain a positive performance of the flow meter.

It is common practice to standardise the maximum differential head of the flow meters and to dimension the Venturi tube or orifice plate to suit the prevailing conditions. In U-tube meters, a differential head suitable for a wide range of flow conditions is one which corresponds to 100in. W.G. In Continental designs in connection with U-gauges with specially shaped limbs, there are two ranges :—

(1) For a differential head of 2000 mm. W.G. (about 80in. W.G.).

(2) For a differential head of 6000 mm. W.G. (about 240in. W.G.).

The U-tube type of flow meter is specially adaptable to the high differential heads which have to be employed in the case of measurement of large quantities of high pressure steam for which the floating bell and ring balance meters would become of impracticable dimensions.

The latest developments in the field of flow meters in Great Britain, as well as on the Continent, seem to indicate a preference for two types of flow meters, namely, the U-tube type for high static pressures and the ring balance type for lower pressures and small differential heads. Both these types of meters are very adaptable to different conditions, due to the fact that they can be easily designed to be applied for several values of the maximum differential head.

In the U-tube manometer, this is obtained by interchangeable limbs with different cross sections, whilst in the ring balance the control weights are interchangeable. Another feature common to the U-tube and ring balance is that the amount of the filling liquid does not influence the reading, provided in the case of a U-tube manometer the zero setting has been adjusted.

To enable a comparison of the various types of mechanical fluid flow meters to be made, the more important data regarding range and application have been compiled in Table II, the data only referring to the usual standard designs.[19] Other meters, therefore, with special dimensions may be available, but these cannot be mentioned here, as it would result in an unnecessary complication of the table.

*(To be continued.)*

TABLE II.—*Range and Application of Types of Flow Meters.*

| Type of flow meter. | Parallel-limbed U-tube. | Shaped-limb U-tube. | Shaped float. | Thin-walled bell. | Dines bell. | Floating bell with displacer. | Tilting U-gauge. | Ring balance high-pressure type | Ring balance low-pressure type. |
|---|---|---|---|---|---|---|---|---|---|
| Normal field of application | All media | All media | All media | Air and gas | All media | Air and gas | All media | Steam and water | Air and gas |
| Static pressure, lb. per square inch— | | | | | | | | | |
| (*a*) Normal | 500 | 500 | 500 | 10 | 500 | 10 | 500 | 500 | 30 |
| (*b*) Maximum | 2000 | 3000 | — | — | — | — | — | 1000 | — |
| Differential head, in., W.G.— | | | | | | | | | |
| (*a*) Normal | 100 | 80 or 240 | 100 | 1 | 53 | 2 | 75 | 60 | 1 |
| (*b*) Maximum | — | 700 | — | 15 | 330 | 5 | 170 | 100 | 4 |
| Interchangeable range (differential heads) | 50 or 100 or 200 | Not used | Not used | Not used | Not used | Not used | 75 or 120 or 170 | 60 or 80 or 100 | 1, 2, 4 |
| Normal filling liquid | Mercury | Mercury | Mercury | Water or oil | Mercury | Water or oil | Mercury | Mercury | Water or oil |
| Quantity of filling liquid | Not critical | Critical | Not critical | Not critical | Not critical | Not critical | Critical | Not critical | Not critical |
| Temperature error (due to change in density of filling liquid) | Small | Small | Small | Small | Small | Small (water) large (oil) | Small | None | None |

[18] The same principle of applying a variable torque is illustrated in British Patent Specification, No. 374,039, 1931, in which the control weight is suspended from a system of links, no cam being used.

[19] Some of the data given in this table has been taken from "Fluid Meters," A.S.M.E. (*l.c.*).

# The Public Works, Roads, and Transport Exhibition.

No. IV.

*(Concluded from page 565, November 29th.)*

### STOTHERT AND PITT, LTD.

BESIDES various of their well-known mixers, screens of the Symons vibratory type and the machinery bed of a standard No. 0 multi-bucket excavator, Stothert and Pitt, Ltd., of Bath, were exhibiting a continuous oil-fired dryer mounted on channel skids and complete with feed and discharge chutes and arranged for oil firing. The drum is lagged with asbestos to conserve the heat, and is fitted with two grooved friction rings running on four cast iron grooved pinions. Internal lifting blades are fitted to the drum to expose the materials thoroughly to the heat, while the moisture is drawn through the drum by means of an electrically driven induced draught fan. The blower fan is fitted with a separate electric motor. This fan supplies the air for atomisation. The atomised oil is forced by the fan into a combustion chamber, where the resultant mixture is readily ignited. The heat can be controlled by air and oil-regulating valves. A 50-gallon oil service tank is mounted at the discharge end of the dryer, from which oil gravitates to the burner.

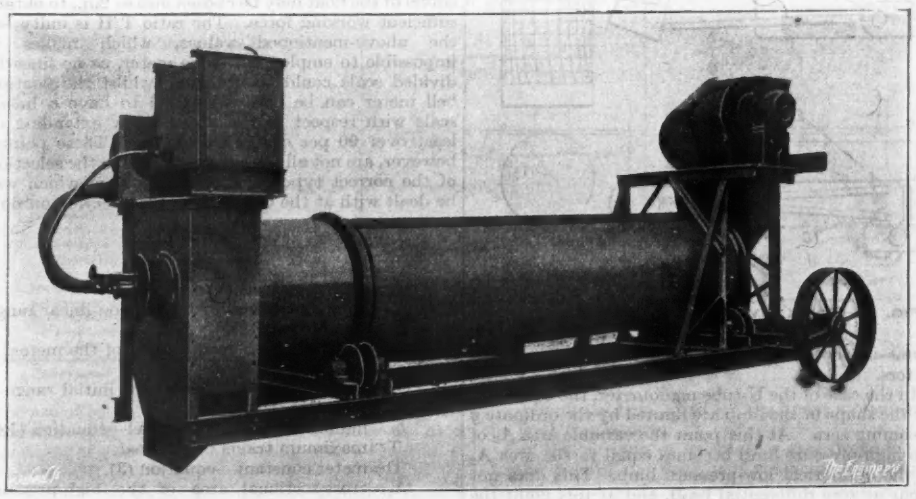


FIG. 53—OIL-FIRED DRYER—STOTHERT AND PITT

### THE PATERSON ENGINEERING COMPANY, LTD.

On the stand of the Paterson Engineering Company, Windsor House, Kingsway, W., was displayed a complete ozone equipment for sterilising water supplies either for drinking or for swimming baths. The equipment showed features of plants capable of sterilising approximately 4 million gallons daily. Ozone is an ideal sterilising agent; no undesirable chemical substances are introduced into the water; no objectionable taste is produced; the appearance, odour, and taste of the water are markedly improved. In recent years the price of electrical energy has fallen

to a level which permits of ozonisation at a reasonable cost, having regard to its many advantages. In addition, a range of chloronomes and ammoniators was on view. An automatic "Basex" water softener in which the regeneration and washing processes are all automatically controlled was displayed, a Paterson dry chemical feed machine, such as is used for measuring and administering chemical reagents for water purification, and other equipment.

THE LINER CONCRETE MACHINERY COMPANY.

THE ENGINEER has described in the past most of the products of the Liner Concrete Machinery Company, of Newcastle-on-Tyne. A new machine in the firm's exhibit at the Public Works Exhibition was the "Kelpie" concrete mixer of 7/5 cubic foot batch capacity. In this machine the superstructure is dispensed with, as will be seen in Fig. 54. A reduced size of machine results, giving greater ease of handling to the mixer. As in all Liner machines, ball bearings are fitted throughout, and in addition the drum spindle is not passed through the drum, but is fitted outside in a cup-like depression in the skin of the drum, thus ensuring that no grit can enter the drum journals from the drum contents. The method of supporting the drum bearings is between two channel sections which pass across the closed end, forming a base to take the weight of the drum during mixing. For tilting purposes they are attached at one end to the outside of an internal toothed ring which is rotated by the hand wheel and pinion visible in Fig. 54, at the other end by a ring of the same diameter, through the centre of which passes the mixing pinion to engage the diametral toothed ring which rotates the drum. The whole unit with the hopper removed can pass through an opening 6ft. 3in. high by 4ft. 3in. wide, and, in addition, its low centre of gravity gives it a surprising stability for negotiating ramps, auto-lorries, or for other purposes.

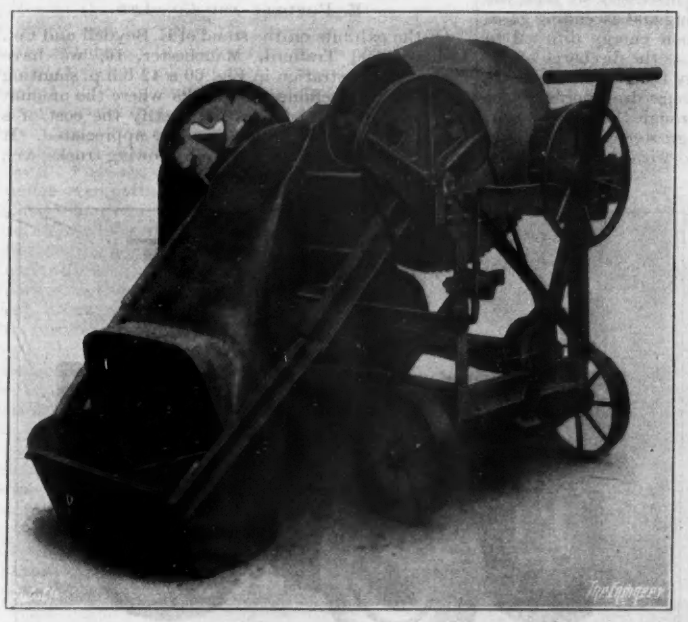


FIG. 54—7 : 5 CUBIC FOOT CONCRETE MIXER—LINER CONCRETE

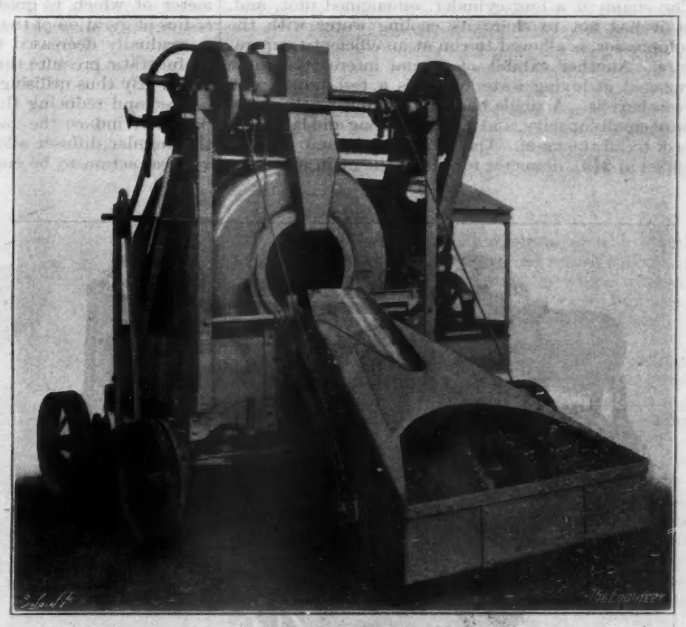


FIG. 55—14 : 10 CUBIC FOOT CONCRETE MIXER—MILLARS'

R. H. NEAL AND CO., LTD.

A useful machine, which has been designed for general all-purpose excavator work and to combine the advantages of a continuous bucket line trencher with the various duties performed, with different equipment, by the usual shovel excavator, is the Neal "Rapid" excavator. As may be inferred from Fig. 56, the main superstructure does not revolve, allowing the machine to work in confined spaces. A 200 deg. swing of the boom is provided, which should suffice for normal use in most cases.

The main machine is mounted on crawler tracks of very strong design, and is driven by heavy roller chain through a differential gear, which, combined with "frictional steering," permits of most accurate and sensitive steering at the slow speeds necessary for the continuous bucket line trencher. Three speeds, forward and reverse, are provided for ordinary travelling, which is a great advantage. The middle speed is used for normal working, whilst the low gear enables the machine to pull out of bad ground which normally excavators would be unable to negotiate. The top gear is used for travelling on good surfaces from job to job, or from one part of a contract to another. Further auxiliary travelling speeds for trench digging are provided, giving 7½ft., 3ft., and 1½ft. per minute. Both crawler tracks may be locked when the machine is working as a navvy skimmer or back digger. Adjustment is provided on the crawler tracks for tightening the tracks and the driving chains. The main castings of steel make up the front bed-plate and the gear-box. The gears are machine-cut steel operated by selectors and controlled by a gear lever operating through a gate. The power unit is either petrol, paraffin, or oil. The Industrial "Fordson" unit is used for petrol or paraffin, giving 31 or 24 b.h.p. respectively, and a "Lister" two-cylinder oil engine is recommended for use with crude oil as fuel. The main engine clutch is Neal's special Ferodo-lined toggle clutch. The drive is taken to the main shaft by triple roller chain running in an oil bath. Neal's special Ferodo-lined external contracting reversing clutches are mounted on the main shaft driving machine-cut bevels, which, in turn, drive the gear-box main shaft. An auxiliary gear-box shaft drives the slewing bevel, which is replaced by a special worm shaft for the ultra low speeds necessary when the machine is being used as a continuous line bucket trencher. Two hoist drums are provided with tapered drums for operating as a normal drag and hoist excavator. They are operated by "servo" Ferodo-lined band clutches of ample size and are fitted with large brake bands, also Ferodo lined. The drums are removed and replaced by an auxiliary boom hoist gear-box for the small trencher attachment. The main controls of the "Bowden" wire type, are so arranged as to require very little effort by the driver and are very sensitive. The normal boom is of electrically welded plate and box sections. The bucket of ¼ cubic yard capacity is so designed that either its hinged bottom or back can be secured, thus enabling the same bucket and boom with arm to be used by different assembly to act as shovel, skimmer or back acter. The boom will serve as a crane jib with a capacity of 30 cwt. The continuous bucket line trencher is fitted with 12in. wide buckets, which will dig up to 15in. wide, with side-cutting teeth attached to depths of 4ft.

The most important feature is the method of emptying and cleaning the buckets. This is done in the same manner as that on the larger machines of this type. Given suitable ground, this trencher will dig small trenches at the rate of 120 yards per hour.

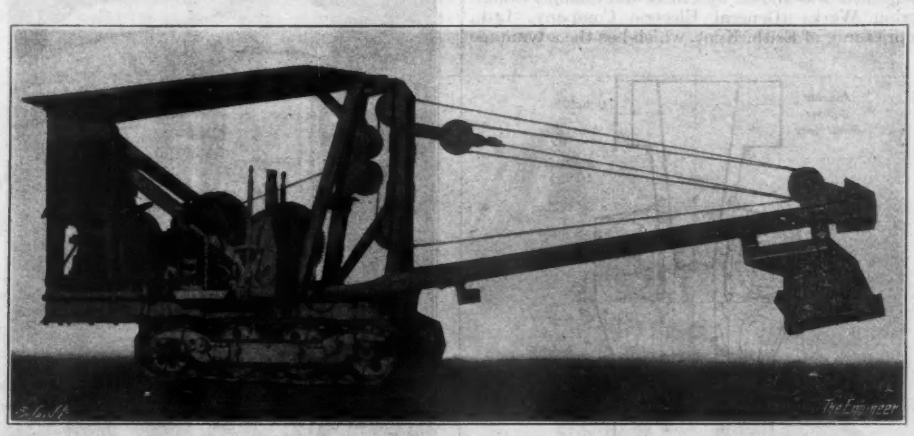


FIG. 56—QUARTER YARD "RAPID" EXCAVATOR—NEAL

MILLARS' MACHINERY COMPANY, LTD.

In Fig. 55 is illustrated the 14/10 N T concrete mixer which was exhibited by Millars' Machinery Company, Ltd., of Pinner's Hall, E.C.2. It is fitted on a four-wheeled chassis, with Ackermann steering. The wheels are the firm's improved type, with double steel angle rims and heavy flat bar spokes. They are 24in. diameter, with 5½in. wide treads. Three-point suspension is provided when travelling, but when mixing a steel adjustable jack is provided to make a fourth suspension point. The wheels and axles are constructed so that either end or side discharge may be arranged without the use of any extra parts. An 8/9 b.h.p. single-cylinder, vertical, hopper-cooled petrol engine, running at 600/650 r.p.m., provides the power, magneto ignition and a governed throttle being fitted. Either a petrol/paraffin or an oil engine are available as alternative extras. Renold steel chains take the drive to the countershaft, and thence to the top shaft. A one-nut chain adjustment is provided. All bearings, except the drum rollers, have replaceable gunmetal bushes, and the drum rollers are mounted on double ball bearings. The mixing drum is of steel, 51in. inside diameter and 38in. inside width. Pressed steel ends are fitted with rounded corners to prevent clogging. The body plate is ¼in. thick, the end plates $\frac{5}{16}$in. Renewable steel tracks, 2½in. wide by 1in. thick, reinforce the drum and ends. Six mixing blades of steel plate and three spade blades impart a lifting, pouring, and spading motion to the aggregate, assisted by the position of the discharge spout during mixing. The drum rollers are of cast iron, 11in. in diameter, the ball bearings having helix adjusting collars. The driving gear ring is of the bevel type, cast in two sections from a machine-cut aluminium pattern. The bevel pinion is of malleable iron. The loader bucket has a capacity of 14 cubic feet and an overload capacity of 15·5. It is constructed of No. 10 gauge steel plate stiffened with flats and angles. It is power-operated, is mounted on Millars' patented double-pivoted hinge, and is designed to give an angle of discharge of as much as 50 deg. Millars' automatic shaking gear and single-lever automatic control are fitted. Hoisting is effected by a steel bushed roller chain from the bevel pinion shaft, a Ferodo-lined cone clutch being interposed. The top shaft is of mild steel equipped with a Ferodo-lined band brake. The bucket is raised on steel wire reeved on equalising pulleys of large diameter. The discharge chute is constructed of steel plate in a manner allowing easy renewal. The operation is by hand lever and links designed to give it an extra steep discharge angle.

THE LEAD WOOL COMPANY, LTD.

In addition to the many products designed to meet the needs of those handling any type of piping and which have been known for several years to

engineers, the Lead Wool Company, Ltd., of Snodland, Kent, was exhibiting this year the compressor shown in Fig. 57. It is designed to compress 130 cubic feet of free air per minute in two stages, the two side cylinders being the L.P.'s while the centre cylinder is H.P. The valves are large and provided with adequate cooling ribs, air cooling being used for the compressor. From the L.P. cylinders the air is taken to a large intercooler of the detachable element type fitted to the compressor end of the machine in a manner similar to the engine radiator at the other end. An H.P. cooler is also used before the air enters the reservoir. It is formed by further elements fitted on the end of the machine. Off loading is accomplished by automatic valves in both H.P. and L.P. manifolds, and, in addition, a centrifugally operated clutch is interposed between the engine and the compressor. The engine is a four-cylinder, oil-engined unit, and, as it has not to share its cooling water with the compressor, is allowed to run at an efficient temperature. Another exhibit of special interest to those engaged in laying water pipes is a test pump with twin barrels. A single-barrel pump must necessarily be of small capacity, and it is thus a long and laborious task to fill the main. This twin-barrel pump has one barrel of 2¾in. diameter for filling the main up to the necessary initial pressure, and another barrel of 1½in. diameter for applying the final pressure for testing purposes. Either barrel can be brought into operation instantly; thus time is saved.

The pump is mounted on a tripod for placing over a bucket or other receptacle, or it can be mounted upon a tank to make a self-contained unit.

### Fraser and Chalmers Engineering Works.

An interesting model of the Cheltnam "Micron" precipitator was shown by Fraser and Chalmers Engineering Works (General Electric Company, Ltd., Proprietors), of Erith, Kent, which has the advantage that it provides dry precipitation of dust as well as selective operation. As shown in Fig. 58, its action is on the cyclone principle. Ordinary cyclones, however, depend for their action on the difference in density between the carrying medium (air or other gas) and the solid matter or dust to be precipitated, and any attempt to increase the degree of separation of dust from gas by raising the inlet velocity intensifies a phenomenon by which the lower of the two vortex rings set up by centrifugal force re-entrains part of the dust that is forced to the shell, carrying it upwards with the gas to the discharge pipe and out of the cyclone. The Cheltnam patented design employed in the "Micron" precipitator overcomes this entraining action by the addition of a patented compartmenting and shunting cone, which, providing a lower boundary terminating the lower pair of vortex rings, allows a shunt current to pass to a secondary chamber below, where a further pair of vortex rings is set up. A further feature of the "Micron" design is the provision of a patented annular diffuser in the outlet pipe. This consists of a definite core or thimble corresponding to the inert core set up in the centre of the body and providing an outlet annulus, the diameter of which is gradually increased so that the radius of gyration of the rotating and ascending gases is gradually decreased and their energy diffused to useful static pressure that assists the discharge of the gases. By thus utilising energy that would otherwise be lost and reducing the pressure drop necessary to propel or induce the gases through the precipitator, the annular diffuser allows a greater centrifugal and vortical action to be employed with the expenditure of less energy or power than in other designs. Another exhibit of interest was the "Sherwen" electromagnetically operated screen. The "A.C." model has the vibrator fitted at the top of the fixed frame. It consists of two former wound coils mounted on a vee-shaped laminated core; the coils are connected in series with a Westinghouse half-wave metal rectifier. An armature bar mounted on hickory springs holds a laminated armature just clear of the stationary core. On switching on the current the armature is drawn forward against spring pressure during the first half of the A.C. cycle; during the second half of the cycle the rectifier prevents the current from passing, enabling the springs to accomplish the return stroke. The live screen frame is held by a flat steel spring at its lower end, its upper end being supported on heavy spiral springs. A 50-cycle A.C. supply will produce intense vibrations at the rate of 3000 cycles per minute, the intensity being variable by a rheostat that controls the current supply. The manner of supporting the lower end of the live frame allows of only a slight movement at that point; the motion is greatest at the upper end, where a quick sizing of the material is beneficial, since it enables the bulk of the undersize to be taken out at the top, leaving the lower part free to deal with the more difficult separation of the particles near aperture size. The gradual decrease in the amplitude of the vibrations towards the discharge end also has the effect of restraining any particles fine enough to pass through the screen from bouncing down the surface as the stream of material thins out.

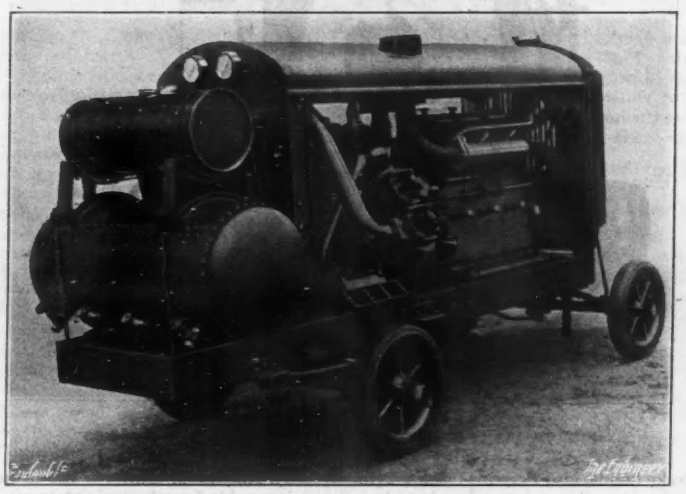


FIG. 57—PORTABLE AIR-COOLED COMPRESSOR—LEAD WOOL

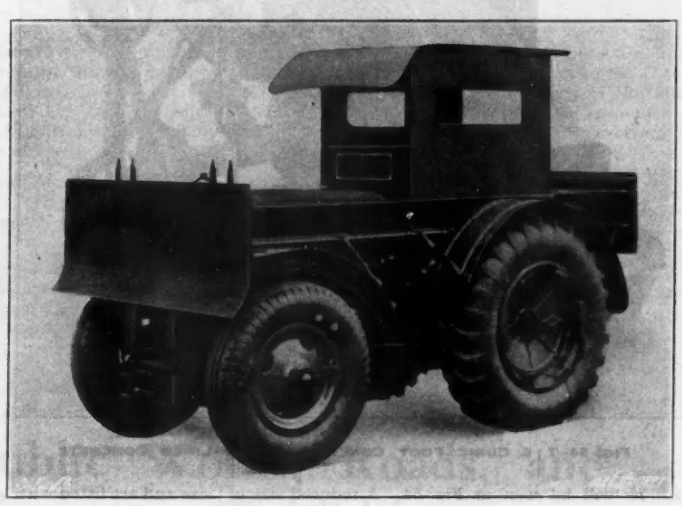


FIG. 60—42 B.H.P. SHUNTING TRACTOR—BOYDELL

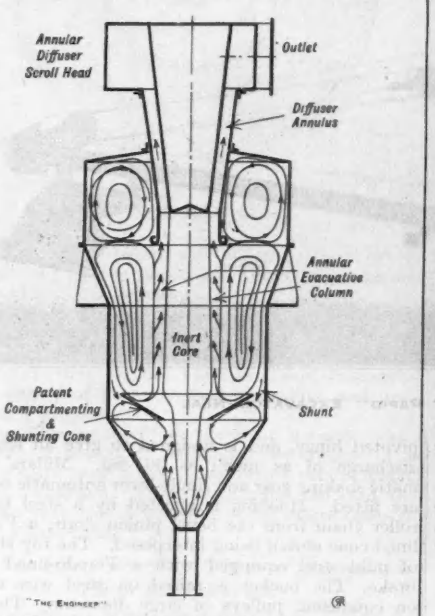



FIG. 58—CHELTNAM "MICRON" PRECIPITATOR—FRASER AND CHALMERS

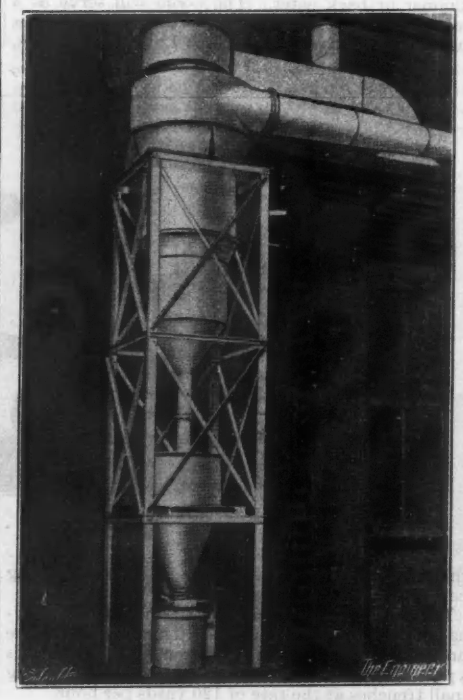


FIG. 59—CHELTNAM "MICRON" PRECIPITATOR—FRASER AND CHALMERS

### E. Boydell and Co., Ltd.

Of the exhibits on the stand of E. Boydell and Co., Ltd., of Old Trafford, Manchester, 16, we have chosen for illustration in Fig. 60 a 42 b.h.p. shunting tractor. Its usefulness in works where the amount of shunting required does not justify the cost of a shunting locomotive will be readily appreciated. It can be used for various other jobs, towing trucks, &c., in between marshalling operations. The engine is a four-cylinder of 4½in. bore by 5in. stroke, developing 42 b.h.p. at 1500 r.p.m. An impulse magneto is fitted and either petrol or petrol-paraffin carburation. It drives the tractor through a multi-disc clutch immersed in oil and a three-speed and one reverse constant-mesh gear-box. The ratios are 17·74 : 1, 44·46 : 1, 81·87 : 1, while reverse is 46·39 : 1. All bearings in the transmission are of the ball or roller type, while the wheels are heat-treated alloy steel forgings. The rear axle is of heat-treated high-carbon steel and is of the semi-floating type. It houses a four-pinion differential gear driven by the 17–1 worm and wheel final drive. The front axle of hand-forged heat-treated steel is suspended by transverse leaf springs. The buffer frame is of rolled steel channels and angles arranged so that all pushing or pulling strains are transmitted direct through the back axle and do not stress the front suspension system. It is attached to the front axle on a single support. Buffer bars of ½in. steel plate are fitted to each end. They are 5ft. 6in. wide and the front plate is curved as shown in Fig. 60 to overcome any tendency of the tractor to "rear" when pushing trucks. The rear plate is flat. Suitable coupling gear is fitted and the cab provides adequate protection for the driver, the windscreen being of splinterless glass. The machine is likely to prove a useful adjunct in many works and is adequately constructed to withstand the strains it is certain to receive in service.

### Hoenig Building System, Ltd.

The waste of space entailed by the provision of staircases, halls, and corridors in the orthodox building, as well as the advantages which would arise if wheeled vehicles could be driven from floor to floor, has led to the introduction of the constructional method which was demonstrated by Hoenig Building System, Ltd., 68, Victoria-street, S.W.1. A series of models was used and the system was ingeniously shown by this means. The patents which the firm holds, and for the use of which it grants licences to architects, structural engineers, &c., cover the use of rooms on varying levels within the building, so that by going the length of the building the path followed has risen by the height of one room. Assuming this height to be, say, 12ft., it follows that for each room traversed in the length of the building, say, six, a proportional fraction of 12ft. height must be gained; in other words, 2ft. per room. The building is therefore constructed six rooms long, each room being 12ft. high and each room being at a level

2ft. above its predecessor. Assuming the rooms to be 20ft. long, then it follows that a ramp could be built along this path with a slope of 1 in 10. Although these figures are illustrative, the system supposes the construction of a building far longer than 120ft., in which case the slope necessary would be far less than 1 in 10. Alternatively, the use of a continuous slope would be given up and only short ramps used from room to room, the main part of the room floor being quite flat. Having gained "one floor" height in the length of the building, the path is carried across the building and returns along the opposite side, still rising by the same amount, and forming a spiral round the building. When the top storey has been gained by this means, the descent is accomplished by another spiral system which starts at the diagonally opposite corner and returns to an exit, also diagonally opposite the entrance. The two paths, up and down, never meet, but are at the same level at the mid point in their traverse, the one on one face of the building and the other the opposite face. Use is made of this fact to allow a change from the upward to the downward path at each "floor" level. Thus, perfect "one-way traffic" is obtained. In addition, the protection from fire risk with the Hoenig system is claimed to be much greater than with orthodox building. The draught channels formed by staircase and lift wells are absent, and, further, owing to the change-over paths provided, alternative routes from floor to floor can be arranged, leaving the seat of the fire isolated by fireproof doors. As a method of constructing a multi-storied garage, the system allows the entire area of each floor to be used for parking space with the exception of the actual path through each room, which in any case has to be left clear. No turning or manœuvring room has to be left, as each car comes into the room along its length and need only back off the "road" into a parking space at the side. The system is also recommended for use in factories, warehouses, &c., and the advantage of having lorry transport right through the shops is certainly great. Finally, it is proposed to use this method for the construction of large apartment houses, enabling tenants of flats to park their cars literally "at their doors," and avoid the wasted area known as "public spaces" in such buildings. The structural methods used would seem to present no difficulties with modern building methods. The foundations would be cut in steps similar to the "steps" between rooms. Ventilation and the clearing of exhaust gases would be accomplished by the use of ducts concealed in each of the ramps, a suction system removing the exhaust of each room. No difficulty would arise as to slope as the ramps would be of short length, and a rise of only 2ft. or 3ft. at most. The system is certainly of interest to factory, warehouse, or other building constructors.

### PRIESTMAN BROTHERS, LTD.

There were three excavating machines on the stand of Priestman Brothers, Ltd., of Holderness Foundry, Hull. One was the "Cub" trenching machine, which we described recently; another a Diesel dredger, equipped with a patented gear which enables the operator to plumb the bucket quickly and accurately over the truck; and the "Panther" ¾ cubic yard excavator, which we illustrate in Fig. 61.

This machine is operated by a Diesel engine developing 30 h.p. It has a scoop capacity of 12 cubic feet, and is capable of operating at the rate of two cuts per minute in the material shown in the engraving—tough blue and yellow clay, containing a thin layer of stone. The machine is putting up an excellent performance at this pit. The main features of the "Panther Twelve" are:—Simplicity of construction, making maintenance work a simple matter. Powerful clutches requiring only a light touch on the hand lever to operate various movements. This combined with a comfortable seat, enables the driver to maintain a high speed of operation throughout the working day without fatigue. A live ring of rollers acting as a roller bearing between the superstructure and undercarriage. This live ring is of large diameter, giving such great stability above the race that the machine is as steady as a rock. It also reduces slewing friction, making a high slewing speed possible, whilst absorbing only a small amount of power. The first drive between the engine and the winch is enclosed in an oil bath, which can be opened out for inspection. The gears in the undercarriage are amply protected from dirt and stones by guards which form oil baths. The scoop is of very robust construction, built for a long life in heavy digging.

### WINGET, LTD.

The necessities of modern concrete construction involve a standard of uniformity in concrete mixing which precludes the haphazard methods of batching

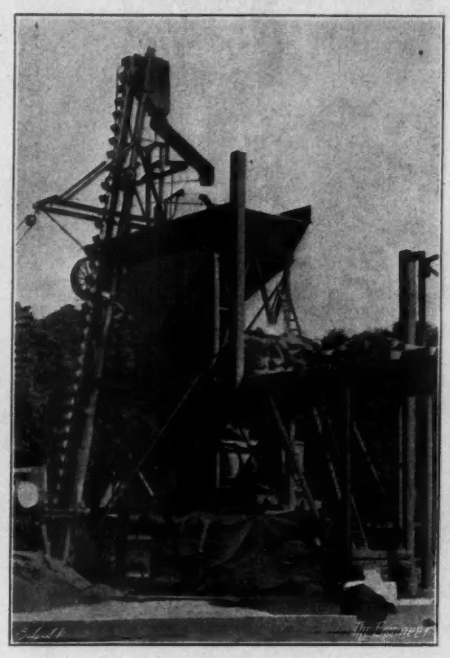


FIG. 62—CONCRETE BATCHING UNIT—WINGET

frequently used in the past. Only batching by weight can produce uniform concrete, certainly having the characteristics laid down by the engineer. The firm of Winget, Ltd., of Rochester, Kent, which has been building batching plants during the last three years, exhibited a portable unit of the type illustrated in Fig. 62. The unit was erected on the stand in working order. It consists of weighing hoppers in which the sand and aggregates are proportioned by weight. They are filled by a bucket elevator. The cement can be stored on an attached platform level with the weigh machines. The weighted contents of the hoppers are discharged into a Winget mixer, through a chute, together with the necessary quantity of cement, and the mixer is set running. Water content is added during mixing from an accurately calibrated tank forming part of the mixer, and after a given period of mixing the concrete can be taken ready mixed to the work in light lorries, or it can be pumped over the work by the Winget concrete pump, which was also exhibited, if the work is close to hand. Finally, for longer distances mixing plant mounted on lorries can be used, so that the mixing takes place during travel, and freshly mixed concrete is provided at the job. These "motomixers" are also of Winget construction.

### BLACKSTONE AND CO., LTD.

The firm of Blackstone and Co., Ltd., of Stamford, exhibited this year all sizes of their well-known B P V type high-speed vertical oil engines, together with the new O P V series. Both engines are somewhat similar in general design. The B P V engine is offered in one, two, three, four, five, and six-cylinder sizes, giving 10 b.h.p. per cylinder at 1000 r.p.m.; whilst the new O P V series, made in one, two, three, and four-cylinder sizes, gives 7½ b.h.p. per cylinder at 1200 r.p.m. Both these engines are worthy of careful consideration by all who are interested in power units for road rollers, lorries, tractors, excavators, cranes, winches, crushers, mixers, compressors, light locomotives, and drilling rigs, as well as for electric generating and pumping sets. Two of the B P V engines were shown fitted with the Sinclair hydraulic coupling, a model of which was also exhibited. Another interesting exhibit was the Blackstone E P V totally enclosed, vertical oil engine, which is made in two, three, four, five, six, seven, and eight-cylinder sizes, developing 40 b.h.p. per cylinder at 600 r.p.m.

### DENNIS BROTHERS, LTD.

There were two principal exhibits on the stand of Dennis Brothers, Ltd., Guildford, a refuse-collecting motor van, and the gully emptier, of which we give an illustration in Fig. 63. There were, however, several other machines of a somewhat similar nature and a portable fire-engine.

The gully emptier has a container of 600 gallons capacity and is carried on a low-load model chassis of 9ft. 6in. wheel base, which gives it a turning circle of 35ft. The wheels are 27in. in diameter and have 6in. tires, single in front and twin behind. The whole of the rear end forms a door, which, with the high-lift hydraulic tipping gear, gives a quick discharge. There is a 4in. galvanised steel suction pipe suspended from a balanced jib. On account of its small size and good turning circle, this machine can penetrate narrow streets and alleys impassable to larger vehicles. As the suction hose can also be operated at the rear, gullies situated in courtyards and one-way streets are easily emptied. Additional apparatus for duties such as channel flushing, cesspool emptying, sewer flushing, and street sprinkling can be provided, if required. A tipping body for refuse can be substituted for the tank in ten minutes. The vehicle is driven by a four-cylinder engine of 24·8 h.p. R.A.C. rating, which will develop 60 b.h.p. when running at 2250 r.p.m. The gear-box gives four speeds forward and a reverse. The air pump, which is used to create a partial vacuum in the tank, to suck up the contents of the gullies, is of the rotary type, and can also be used as a compressor. The tank is galvanised inside and out, and is divided into two compartments, 300 gallons for clean water and 300 gallons for sludge. Provision is made for connecting the compartments so that total capacity of the tank can be used for sprinkling, channel flushing, sewer flushing, or cesspool emptying, assuming such equipment to be fitted. The whole of the rear end forms an emptying door, with a rubber ring to provide an air-tight joint. The tank is mounted on pivot brackets at the rear for tipping. The forward end of the tank rests on steel legs. An automatic cut-off valve is housed in a separate compartment to prevent overfilling. A 2in. valve and length of hose are connected to the forward compartment for resealing. On machines where it is intended to operate the suction pipe at the rear, an extension of the resealing pipe is provided, together with a suitable length of

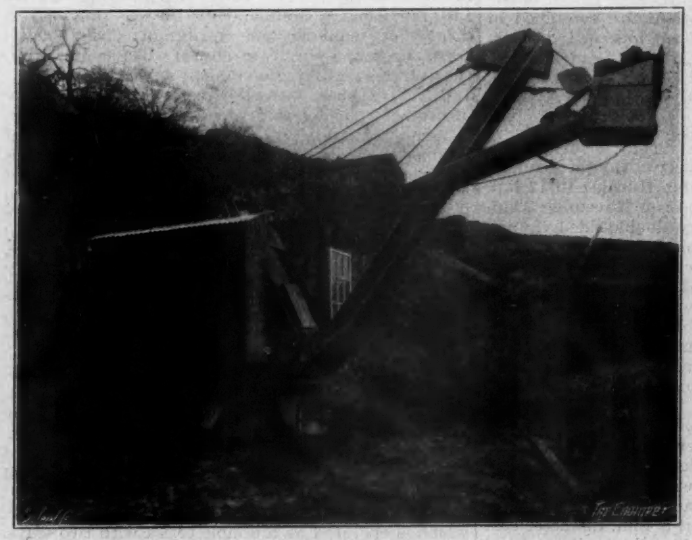


FIG. 61—"PANTHER" THREE-EIGHTH YARD EXCAVATOR—PRIESTMAN

FIG. 63—GULLY EMPTIER—DENNIS

hose and valve, so that gullies which are emptied from the rear of the vehicle can be resealed without difficulty.

### REAVELL AND CO., LTD.

Among the representative display of their products, Reavell and Co., Ltd., of Ranelagh Works, Ipswich, exhibited an oil engine-operated compressor set running at 1000 r.p.m. and capable of providing air for the operation of four heavy type concrete breakers. The engine used is a four-cylinder National of 4½in. bore by 6in. stroke, developing 34 b.h.p. It is fitted with forced lubrication and the National self-cleaning atomiser. A centrifugal governor controls the revolutions of the set. The engine drives the compressor through an automatic restrained centrifugal clutch, which connects the two machines when roughly half engine speed has been reached. In addition to facilitating hand starting, this arrangement allows the engine to be run at reduced speeds for adjustment purposes without running the compressor. The cooling system is by pump circulation through a radiator built in section to facilitate repair, any section being removable without putting the plant out of action. The water passes through the compressor before entering the engine jacket, thus maintaining each machine at its correct temperature. The compressor is a vertical two-cylinder unit. The suction valves are of the piston type, so arranged that the delivery valves do not need to close with the rapidity usually necessary, and therefore allowing compressor efficiency to be maintained at comparatively high speeds. An automatic control system unloads the compressor at a set receiver pressure, reloading it at another set pressure. When the compressor is unloaded the engine speed is automatically reduced to idling.

### FREDERICK PARKER, LTD.

A form of stone breaker or rock crusher which is entirely new to this country, although it has been used to some extent abroad, was exhibited by Frederick Parker, Ltd., of Viaduct Works, Catherine-street (Extension), Leicester, and is illustrated in Fig. 64.

As will be seen from the engraving, it is a double-sided machine, with two jaws crushing against a central roll. As a consequence, it is remarkably

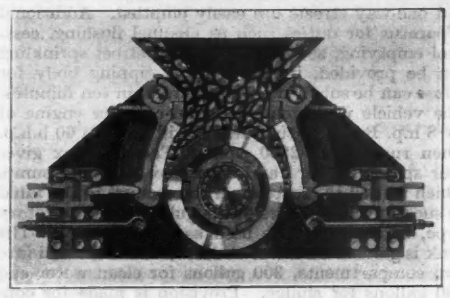


FIG. 64—STONE BREAKER—PARKER

compact. The gap between the roll and the jaws can be set to deliver different sizes on the two sides. It is said that the angle of approach of the concaves and the roll is such that any shaped rock or gravel can be gripped. It is a machine which is intended to reduce the product to a definite size in one operation and not to require the return of any oversize. It is made of steel throughout, and is equipped with oversize ball bearings to reduce power consumption and lubricating costs.

### JONES AND ATTWOOD, LTD.

Among other machines on the stand of Jones and Attwood, Ltd., of Titan Works, Stourbridge, was a working model of the Jones totally suspended "Tractum" chain drive water wheel distributor. This machine is suspended from the central column on a ball-thrust bearing. The patented chain drive gives a positive propulsion without the necessity of a rail or even a wall. The distributor is in equilibrium and is fitted with a short water wheel at the outer end of one arm and a balance of suitable weight and area to compensate for wind pressure at the outer end of the opposite arm. A very low head is required, owing to the use of the waved lip spreaders. No dosing apparatus is required, as the distributor will work with any varying rate of flow and will travel continuously with a flow of one gallon per minute. In addition was shown a working model of the Jones "Fan-Spray" pipe arm sewage distributor. Each jet is fed with sewage from an open weir gate, as in the suspended "Tractum." A governor jet at the outer end of each arm regulates the speed of the machine during heavy flows or sudden flushing due to the dosing syphons. A feature of both these machines is the large holes, which make the possibility of choking very remote. The smallest hole through which the sewage flows is in the form of a slot, 2½in. by 1½in., a point worthy of consideration by engineers and surveyors desiring distributors which can be left working without attention for considerable periods. The method of controlling the flow to ensure equality of distribution over the whole surface of the filter is the same for all models. Weir gates are provided which vary in width in direct proportion to the area covered by each individual spreading unit, whether a "Fan-Spray" or a waved lip tray.

### GEORGE KENT, LTD.

The firm of George Kent, Ltd., of Luton, Beds., provided a demonstration of the measurement of water flowing through open channels, by means of a model flume with transparent sides. Besides various recording instruments which the firm is manufacturing and which were demonstrated in action recording depths and flow on the model flume, the new V.F. type recorder was shown in operation recording the flow through a drowned flume where it becomes necessary to provide a recorder which will multiply the depth at the throat by the square root of the difference

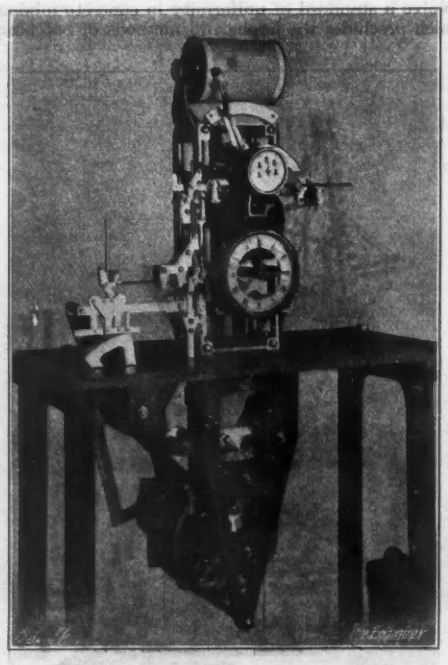


FIG. 65—V.F. FLUME RECORDER—KENT

between the upstream depth and the depth at the throat. This naturally involves the use of two floats and a rather more complicated recording mechanism. The Kent V.F. type recorder performs this duty in a most reliable manner, as well as being perfectly suitable for free discharge conditions as mentioned above. The mechanism includes a differential gear, whose resultant movement is equal to the difference between the upstream depth and the throat depth. This movement rotates a square root cam whose feeler arm operates a rack which moves in a vertical direction, the movement being proportional to the square root of the difference between the upstream and throat depths. The other part of the mechanism consists of a carriage which moves in a horizontal direction and is operated by means of the end wheel which is rotated by the float measuring the depth in the throat of the Venturi flume. The two motions are combined in such a manner that the resultant motion is proportional to the product of the throat head and the square root of the differential head; that is to say, the product is proportional to the rate of flow.

### ROBERT HUDSON, LTD.

Robert Hudson, Ltd., of Raletrux House, Meadow-lane, Leeds, was exhibiting the Hunslet 10/12 h.p. oil engine locomotive, described on November 22nd. The firm also exhibited heavy double-sided tipping wagons of 27, 36, and 54 cubic feet capacity. Two of the firm's new type contractors' wagons were also on view, one being of 18 and one of 27 cubic feet capacity. All these vehicles were equipped with the "Faro" pressed steel axle-box. A 20 cubic foot capacity standard U-shaped mine wagon fitted with Cabo wheels and axles was also on view. Several models of the "Faro" axle-box fitted with high-duty ball bearings and of the "Cabo" wheels and axles with high-duty taper roller bearings were also shown. Finally, a brick dryer car and a small clay tub were displayed. Track materials made by Robert Hudson, Ltd., were represented by a Hudco reversible switch, 9ft. long, suitable for 24in. gauge rails; a Hudson easy turnout, a 46in. diameter cast iron ball-bearing turntable of the raised rail type, and a 42in. diameter turntable of the portable steel type.

### GOODWIN, BARSBY AND CO., LTD.

On the stand of Goodwin, Barsby and Co., Ltd., St. Margaret's Iron Works, Watling-street, Leicester, there was a variety of stone-crushing plant, including the machine illustrated by Fig. 66. It is of that type in which hammers hinged to a rapidly rotating shaft fling the stone against a breaker plate and smash it by impact either with the hammers or the plate. It is said that this results in flinty gravel being broken up into approximately cubical pieces instead of pieces with razor edges. The breaker is fitted with machined renewable bearings bedded into bored seatings. It will reduce material down to ¾in. gauge and is made in four sizes having capacities from 10 to 60 tons per hour, and corresponding power consumption of 12 b.h.p. and 60 b.h.p. There were also some jaw breakers, fine-crushing rolls, a paddle

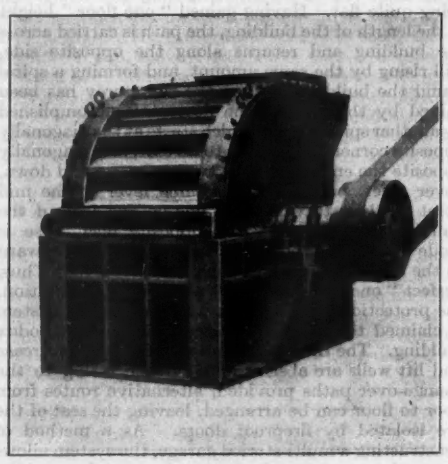


FIG. 66—ROTARY HAMMER GRANULATOR—GOODWIN

mixer for tar or bituminous compounds, and a double-deck mechanically operated vibrating screen.

### OTHER EXHIBITORS.

The exhibits of a number of other firms deserve mention. Sir W. G. Armstrong, Whitworth and Co. (Engineers), Ltd., of Newcastle-on-Tyne, 1, confined themselves to pneumatic machinery for contracting work in the form of such plant as oil-engine-driven portable compressing sets, with which our readers have been made familiar by previous descriptions in THE ENGINEER; a pneumatic concrete breaker; a clay digger; a demolition tool; and a heavy-duty backfill rammer. The Climax Rock Drill and Engineering Works, Ltd., of Carn Brea, Cornwall, exhibited a range of drill-sharpening machines and milling machines, together with the firm's range of drills. In addition, various pneumatic tools and exhausters with their accessories were on view. Hathorn, Davey and Co., Ltd., of Sun Foundry, Dewsbury-road, Leeds, were demonstrating the Gargantua disintegrator on the stand of Wm. E. Farrer, Ltd., of Birmingham. Among a large range of flexible shaft operated machines, the Flextol Engineering Company, Ltd., of 112, Grosvenor-road, S.W.1, were exhibiting an interesting tile-grinding and polishing machine. It is a high-speed machine designed for wet grinding and for polishing. The tile is rotated in a horizontal plane and the grinding performed by a cup grinding wheel revolving at high speed in the opposite direction. The spindle carrying the cup wheel is provided with a rise and fall, in addition to radial movement. The finished surface is claimed to be dead flat. The Dover Engineering Works, Ltd., of Dover Ironfoundry, Dover, provided a display of manhole and inspection covers of all sizes, types, and purposes, most of which came within the well-known Elkington range. A. A. Byrd and Co., Ltd., of 11, Queen Victoria-street, provided a display of cement proofing work done with Tricosal water-proofing medium, and also exhibited a range of "Superpneumatic" compressor hosing, and other specialised rubber products. Finally, samples of "Metaform" steel shuttering were shown. William Bunce and Son, of Ashbury, Swindon, exhibited the Ashbury road-gritting machines, snow plough, and the hygienic pneumatic-tired road litter barrow. A display of perforated metal, pressed steel articles, and woven wire products of all types and sizes was provided by G. A. Harvey and Co. (London), Ltd., of Greenwich Metal Works, S.E.7. Every requirement for lubrication purposes was displayed in the range of exhibits on the stand of Tecalemit, Ltd., Great West-road, Brentford, Middlesex. In addition, the Tecalemit air compressors were represented by various types and sizes. Robert Broadbent and Son, Ltd., of Phœnix Ironworks, Stalybridge, exhibited one of the Blake improved stonebreakers, a set of patent improved crushing rolls and the counter-balanced oscillating screen, a reciprocating machine, which is operated by a double crank with two trays. The trays work in opposite directions and balance each other, thus reducing vibration. The Dorr-Oliver Company, Ltd., of Abford House, Wilton-road, S.W.1, exhibited scale models of the well-known Dorr machines, including the digester, clarifier, flocculator and clarifier, and the detritor. Cooke, Troughton and Simms, Ltd., of 15–17, Broadway, Westminster, S.W.1, exhibited various models of the theodolites and levels manufactured by the firm, including the optical scale theodolite T 63, in which the circle reading eyepieces form part of the telescope, so that the surveyor need not change position when observ-

ing. The circles are read direct to 15 sec. by means of a special form of "grid" scale. The telescope is internal focusing, having a magnification of X 25, and is fitted with stadia diaphragm and screw focusing eyepiece. The Consolidated Pneumatic Tool Company, Ltd., of Egyptian House, 170, Piccadilly, W.1, had a selection of pneumatic machines on view, which covered almost every purpose for which compressed air is used. Industrial engines of the high-speed type from 5–10 h.p. to 20–48 h.p. were displayed by Morris Motors, Ltd. The National Gas and Oil Engine Company, Ltd., of Ashton-under-Lyne, showed a horizontal single-cylinder 16 h.p. model, two vertical single-cylinder models of 5 and 7 h.p., and a 25 h.p. three-cylinder vertical engine out of their extensive range. All the engines have high-turbulence combustion spaces, and the well-known National feature of valves removable without disturbing cylinder heads or pipe joints. Non-choking atomisers are also fitted. Bell Brothers (Manchester, 1927), Ltd., of Calder Ironworks, Denton, Manchester, showed exhibits covering pressure and gravity filters, continuous and base exchange softeners, chlorination and water-hardening apparatus, and the allied chemical plant necessary for all types of water treatment. They also showed some special filters for use with other liquids. Parker Winder and Achurch, Ltd., of 8, Gt. Marlborough-street, W.1, were demonstrating the Beresford-Stork and Beresford-Garvens pumps, the manufacturers of which are James Beresford and Son, Ltd., of Cato-street Works, Birmingham 7.

## Letters to the Editor.

*(We do not hold ourselves responsible for the opinions of our correspondents.)*

### FAST TRAINS.

SIR,—I was interested to see Mr. Loftus Allen's letter in your issue of November 22nd, respecting the old L.N.W.R. two-hour Birmingham service of 1902.

As I understand the matter, the first two-hour train commenced to run on August 1st, 1902, leaving Birmingham for Euston at 5 p.m. The working of this train had, however, the important qualification that the run could be done in 115 min., instead of 120 min., whenever the road was clear, and if all other factors were favourable. The drivers were instructed accordingly. With the shorter timing the average speed for the 113 miles became 59·5 m.p.h.; but, from the public point of view, the published journey time continued to be 120 min., representing an average speed of 56·5 m.p.h.; the lesser allowance of 115 min. being optional and depending on circumstances.

The inaugural run, on August 1st, 1902, from Birmingham, was made with the Webb four-cylinder compound, No. 1960, "Francis Stevenson" ("Alfred the Great." class), and the load, as stated by Mr. Loftus Allen, was approximately 130 tons, exclusive of engine and tender. The time taken, according to the late Mr. Charles Rous-Marten, was four seconds under the 115 min. Mr. Rous-Marten remarked in his article that the task could easily have been accomplished by one of the "Precedent" 2–4–0's, or by a "Lady of the Lake" single, but that the object in using so powerful an engine as the "Francis Stevenson" was to avoid the running of high speeds downhill in order to keep to the accelerated timing, if otherwise feasible.

F. W. BREWER.

Stevenage, Herts,
December 2nd, 1935.

### SINGLE-ARCH MASONRY DAMS.

SIR,—In the two very interesting articles on Single-arch Masonry Dams by Mr. George Bransby Williams, the rarity of this type of dam in Great Britain is stressed at the beginning and at the end.

The author states that the only British examples known to him are some comparatively small curved dams in Scotland.

I should like, therefore, with your permission, to remind you and your readers of the Maentwrog Dam in North Wales, which is a single-arch concrete dam depending on its curvature for stability. It is 120ft. high, 210ft. radius, 42ft. wide at the base, impounding 1200 million cubic feet of water, and was completed in 1927.

JOHN TUDLE EVANS,
Engineer.

Trent Navigation Company, Nottingham,
December 2nd.

### DOMESTIC REFUSE DISPOSAL.

SIR,—In your issue of November 22nd there is a letter from "Domesticus," headed "Domestic Refuse Disposal."

I should like to congratulate him on his advocacy of paper bags for house refuse. This is the practice in Canada, where it is compulsory. The saving effected were the idea copied here would be very considerable, and a serious danger to the public health removed. We had a case in this town a short time ago of a prominent citizen getting some refuse blown into his eye, with the result that he was laid up for four months.

House refuse collected in this way—or any other way for that matter—should be incinerated without any attempt being made to salvage the paper, &c., nor should it be handled in any way.

The millennium would then be in sight so far as house refuse is concerned.

FRANK EVANS.

Brighton, November 30th.

### JOINTS IN CONCRETE PAVING.

SIR,—In my sketch on road joints, on page 570 of your issue of November 29th, a very necessary portion of the roof felt has been omitted. It should run for the length of the overlap on both the vertical and horizontal faces of the first laid concrete, the horizontal section being, of course, for the purpose of preventing the second concrete adhering to the first. Two pieces of felt are used—one running down the left side of the wedge and then horizontally, and the second down the right side of the wedge and a short way round its bottom edge. I think you will agree that most engineers would condemn the method, unless the horizontal layer were placed, because the two concretes would tend to adhere and thus prevent relative movement, which must take place.

H. C. JOHNSON.

Birmingham, November 30th.

### "POWER FOR NOTHING."

SIR,—We have 1 lb. of air at 14·7 lb. per square inch absolute in the cylinder of an engine and at a temperature of 5000 deg. Fah.

Similarly, we have another engine, the cylinder of which contains 1lb. of air at 14·7 lb. per square inch absolute and 60 deg. Fah. We find we cannot get any work out of either of the infernal things. So we bring the cylinders together and let heat pass from one cylinder to the other till both are at the same temperature.

We can now get work out of both cylinders; the air in the first will be below atmospheric pressure and in the second cylinder much above. There is no catch.

Birmingham, December 2nd. F. E. LINDSAY.

## Modern Developments in Railway Signalling.

CONSIDERABLE advances are shown to be taking place in the use of electricity for signalling in a paper on "Modern Developments in Railway Signalling," read by Major L. H. Peter before the Institution of Electrical Engineers on Thursday, December 5th. Regulations governing the operation of facing points by the usual rodding limit the distance of such points to 350 yards, and it was only the introduction of power-operated point machines which made it possible to close redundant signal-boxes and transfer the operation of the points and signals by electrical means to the next signal-box. In the case of the intermediate block posts the signals became power operated instead of manually operated, and track circuits provided the necessary space interval protection previously given by the block telegraph system.

This remote control of point and signal operating mechanisms entailed the use of positive methods of checking the position of point tongues, facing point bolts, and signal arms, and, following the well-established practice of track circuits, normally closed circuits were used throughout. As a main power supply is seldom available within economic distance of the points and signals to be power operated, primary batteries have to be used. The air-depolarised Leclanché type of primary cell is employed in preference to the Edison-Lalande type on account of cost, and in some cases secondary cells kept charged from primary cells form the battery for point machine operation. This method has the advantage that the momentary current of 5 to 8 ampères at 30 volts required for a point machine can be provided from the secondary battery, and as the number of operations per day in these outlying installations seldom reaches fifty and the operation lasts only three or four seconds there is ample time for the primary cells to recharge the secondary cells at a rate which allows a long life to the former. Wherever an A.C. power supply is available the practice is to trickle-charge a secondary battery through a metal rectifier. Cadmium-nickel-iron batteries have proved quite satisfactory for this class of point machine operation.

The price of electrical energy from primary batteries and the cost of their maintenance led to the development of hand-operated generators to supply energy to outlying mechanisms. It has been found that a signalman can generate 120 watts for short periods, and this allows points or signals to be operated in the required time. A primary battery is used to hold the signals clear after the initial effort by the signalman, and a special transfer circuit is used to change from the clearing to the "hold clear" circuit. In the case of the outlying point machine the circuit is arranged to serve the dual purpose of providing the power and to control the direction of rotation of the machine on the same two line wires.

The remote control of points and signals would be impossible without the continuous protection of track circuits, and all developments of electrically operated railway signal systems continue to depend more and more on the absolute integrity of the circuit which shows the presence or absence of a vehicle on the running lines. Developments in track circuits have been many, and although none of these has increased the safety factor to any great degree, each has contributed something in this direction or, alternatively, has assisted in easier application of the main principles.

There have been marked changes in locking frames for power-operated railway signalling. Up to 1928 all these locking frames had some form of mechanical interlocking between levers, and each lever was further controlled by electric locks working in conjunction with the track circuits and signal apparatus. In 1928 a locking frame with the usual levers was installed, but electric contacts and locks were used instead of mechanical tappets and lock dogs. This system has been widely used and possesses very marked advantages. Locking frames with electric interlocking are particularly advantageous for large installations and in such cases occupy less space and give facilities for locking changes not obtainable with mechanical interlocking. It may well be that this change from mechanical to electrical interlocking is itself part of a larger change in which the locking frame itself will give way to a small control desk, and there are many installations where this has already taken place. In such cases the whole of the interlocking is carried out by circuits between relays instead of partially by contacts, circuits, and electric locks on levers.

Together with the change from lever frame to desk control comes the introduction of coded impulses into the system of control, giving a reduction of line wires and the bringing of long lengths of track under the control of one operator. In the modern form of control apparatus the levers are free to be moved at any time and are consequently light and can be housed compactly with the indication lamps referring to them.

Code control can be used with multi-wire or coded systems, but in all cases the small switches are pilots only and do not handle the relatively heavy powers required by point machines, relays, or other forms of contactors being introduced between pilot switch and operating circuits. It is at this point that a change from direct current for primary control to alternating current for the signals is made. The track circuits may be D.C. or A.C., according to the requirement for traction, and the power system for point operation may be electric or electro-pneumatic without affecting the control system so long as suitable changes are made at the pilot relays. In the case of long-distance control it is an advantage to code out the signal and point control orders and to code back into the control point the indications given by points, signals, and track circuits, and several systems of doing this have been installed.

Outgoing codes are initiated by the signalman, who sets up a traffic movement by positioning point and signal levers on his control panel and then presses a button. After this the whole code is transmitted by code relays to the appropriate points and signals at the distant stations. When the points and signals have responded they in turn transmit back their new indications to the control panel by code and lamps are illuminated against the correct levers on the panels. The whole of the interlocking between points, signals, and track circuits is carried out between relays at distant stations, so that the fullest degree of safety is maintained.

The use of codes in railway signalling has not been restricted to the transmission of orders and indications between the operator and points and signals, but has been developed as a means of displaying signal indications in the engine cab. Various forms of cab signalling have been proposed and the Great Western Railway have a large installation of distant signal cab signalling, which has already been described, but the bulk of modern development has been on the lines of "non-contact" systems, either of the "intermittent" or the "continuous" variety. It is in the continuous type that coding plays an important part.

The most recent development in the application of codes to railway signalling is in the track circuit itself. The ordinary closed circuit of track rails and relay has been continuously energised in the past and has been used simply to prove whether or not any vehicle stood between the rails. It has been usual to transmit this information to other relays controlling signals admitting traffic to the section. This has necessitated line wires over considerable distances, and as the need for conveying more information to the driver by an increased number of signal aspects has grown so have the number of line wires increased.

In dense traffic areas where sections are short this is not serious, but where track sections are long the cost of line wires is unduly heavy. By coding the current normally fed to the track circuit at the feeding point and decoding at the relay end, the track rails themselves replace the line wires. The code to be transmitted along the rails is determined by the traffic conditions ahead, and the relay which responds to the code, in turn, controls the signal aspect to be shown.

---

BECAUSE Chicago is built on the shore of a great lake of water of good quality, there is a popular opinion that water costs little or nothing and the reckless use and waste of water has reached an extravagant extent. Few but the waterworks engineers and technical officials realise the high cost involved in the pumping and distribution of the wasted water, and for years past it has been impossible to convince the city fathers of the necessity of metering the consumption in order to keep the cost of water supply within bounds. Under such conditions it has been useless to think of filtering the water, and with increasing pollution only chlorination has been practicable. There has been a change recently, however, partly on account of the possibility of getting Government aid for a filtration project, with metering as an essential factor. The plan provides for three filtering plants to serve different sections of the city, with an initial combined capacity of 1185 million gallons daily, or an ultimate capacity of 1700 million gallons daily. For these three plants the total cost is estimated at £9,300,000. To this must be added £2,300,000 for metering, which will bring the final cost up to £11,600,000. From the operation of an experimental filter plant since 1928 it appears that after preliminary chemical treatment and settling the lake water can be filtered at a maximum rate of 4 gallons per square foot per minute in summer and 2½ gallons in winter. The size of individual filters should not exceed 4 million gallons. Chemical mixing will be done by mechanical agitators for a period of five minutes, followed by a flocculation period of forty-five minutes and a settling period of three hours in double-decked settling basins. Continuous mechanical scrapers will remove the sludge from the basins. The filtered water reservoir will have a capacity of 40 million gallons. For the coagulation, alum or ferric chloride or chlorinated copperas will be used. Chlorine or ammonia chlorine treatment will provide for disinfection, and activated carbon for control of odour and taste.

# Utilisation of Creep Test Data in Engineering Design.*

By R. W. BAILEY, B.Sc.

THE paper relates to basic principles underlying the rational design of parts when the operating temperature is such that creep is the dominating factor. The elastic theory is inapplicable to this case, and the author proposes a relationship between creep rate and a general system of stress which is applied in the analysis of stress and creep distribution in important engineering parts. The paper consists of two parts and a number of appendices. Part I opens with a description of the method used by the author to obtain tensile creep test data suitable for design, both for the case of steady stress and for diminishing stress, as, for example, in bolts. The following cases under creep conditions are then dealt with—parts under bending, and under bending and direct load, cylinders, pipes and tubes under internal pressure with and without heat flow, pipes under internal pressure and subjected to bending and twisting moments about the axis, and discs subjected to loading by centrifugal force. Part II considers creep under compound stress. The author concludes that

(1) Creep occurs on planes where there is shear stress, and is not confined to planes of maximum shear stress.

(2) Creep by shear upon a plane may be influenced by shear stresses upon other planes.

(3) Creep by shear is uninfluenced by the tensile or compressive stress acting at right angles on a plane of shear.

Based upon experimental data upon lead pipes and steel tubes, the author arrives at the conclusion that for an isotropic material the creep rates $C_x$, $C_y$, and $C_z$ in the directions of the principal stresses X, Y, and Z can be represented by the following equations :—

$$C_x=\frac{A}{2}\left[\tfrac{1}{2}(X-Y)^2+\tfrac{1}{2}(Z-X)^2+\tfrac{1}{2}(Y-Z)^2\right]^m \left[(X-Y)^{n-2m}-(Z-X)^{n-2m}\right] \quad . \quad . \quad . \quad (1)$$

$$C_y=\frac{A}{2}\left[\tfrac{1}{2}(X-Y)^2+\tfrac{1}{2}(Z-X)^2+\tfrac{1}{2}(Y-Z)^2\right]^m \left[(Y-Z)^{n-2m}-(X-Y)^{n-2m}\right] \quad . \quad . \quad . \quad (2)$$

$$C_z=\frac{A}{2}\left[\tfrac{1}{2}(X-Y)^2+\tfrac{1}{2}(Z-X)^2+\tfrac{1}{2}(Y-Z)^2\right]^m \left[(Z-X)^{n-2m}-(Y-Z)^{n-2m}\right] \quad . \quad . \quad . \quad (3)$$

where A is a constant for a specific temperature and $m$ and $n$ are constants. In an appendix dealing with the case of cylinders under internal pressure, and where there is heat flow, the author takes A to be represented by $a\,e^{b\theta}$, where $\theta$ is temperature, $e$ is the base of Naperian logarithms and $a$ and $b$ are constants.

The case of simple tension or compression represented by X, Y=0, Z=0, is given by $C_x=A\,X^n$. This equation when the temperature is constant expresses fairly well the relationship between creep rate and stress, at low creep rates, such as are important in practice. For carbon and low alloy steels, the author suggests a value of $n$ equal to 6. The magnitude of $n$ may be derived from tensile creep tests, and that of $m$, as also of $n$, may be obtained from tensile and torsion creep tests upon tubes, as is shown in Part II of the paper. In dealing with rotating discs, the author employs a value of $m$ equal to unity, and for tubes and cylinders where generally larger creep rates are permissible a value of $m$ equal to 2 is taken.

The most important sections of the paper develop rules for design, based upon the general relationships given above.

### PARTS UNDER SIMPLE STRESS.

(*a*) *Tension and Compression.*—Results obtained by means of the tensile creep test would be employed directly for both simple tension and compression.

(*b*) *Shear.*—In an appendix it is shown that the shear strain creep rate $\varphi$, expressed as radians per unit time, is given by

$$\varphi=A\,s^n\,3^m\,(2^{n-2m}+1),$$

where A, $m$, and $n$ are the same as for tensile creep tests, and $s$ is the shear stress, when $m=2$ and $n=6$, $\varphi=45\,c$, where at the same temperature $c$ is the tensile creep rate in inches per inch per unit time, for a tensile stress equal to $s$.

(*c*) *Bending.*—It has been shown by Tapsell and Johnson from tests upon a lead beam that the tensile or compressive stress at a distance $y$ from the neutral axis is proportional to $y^{\frac{1}{m}}$. The stress distribution over the cross section is exhibited by the curve A O B of Fig. 1 By considering the cases of rectangular and diamond-shaped cross sections, the author suggests that the moment of resistance to bending of most sections is given safely by 90 per cent. of the moment of resistance for uniform distribution of stress on both sides of the neutral axis

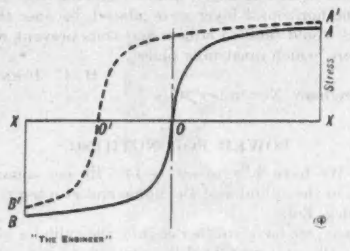



FIG. 1

equal to the maximum value. Or, generally, if $a$ is the cross-sectional area, $g$ is the distance between the centres of gravity of the section areas on each side of the neutral axis, and $f$ is the maximum tensile or compressive stress

$$\text{Moment of resistance (approx.)}=0{\cdot}9\,\frac{a}{2}\,g\,f=0{\cdot}45\,a\,g\,f.$$

The neutral axis divides the cross-sectional area into two equal areas, such that the line joining their centres of gravity is in the plane of the bending moment. An appendix describes a method of finding the position of the neutral axis of a general cross section.

(*d*) *Combined Bending and Direct Load.*—Adding a direct load to a bending moment changes the strain and stress distribution diagrams of Fig. 1 from A O B to A'O'B'. Commencing with a bending moment, progressive increase in the direct load causes the dotted curve A'O'B' in Fig. 1 which has the same form as A O B, to move to the left ; and when O' reaches X, representing the edge of the section, the stress is entirely of one kind, either all tensile or all compressive. Increase in direct load moves the dotted curve A'O'B' further to the left and the part over X O X continues to give the stress distribution over the section. It will be evident that with large direct loading the stress distribution approaches more and more the distribution for elastic conditions. An appendix analyses the case of a rectangular cross section, and Fig. 2 summarises the results of the analysis in a form which enables the creep case to be interpreted from the stress determined in the ordinary way for elastic conditions. Both from Figs. 1 and 2 it is clear that the addition of quite an important direct load to a bending moment brings about but a relatively small increase in stress.

### PARTS UNDER COMPOUND STRESS.

*Thin Cylinder Under Internal Fluid Pressure and Axial Load.*—In Fig. 3 the directions of X, Y, and Z are taken, corresponding to the radial, circumferential, and axial directions in the cylinder. The axial stress Z is variable and may be expressed as $\alpha$ Y, where Y is the constant circumferential stress and X is taken as zero, which for practical purposes would be its value for a thin cylinder.

Introducing the values of X and Z in the general equations (1), (2), and (3) for $C_x$, $C_y$, and $C_z$, gives :—

*Radial Creep of Wall.*—

$$C_x=\frac{A}{2}\left[\tfrac{1}{2}(\alpha-1)^2\,Y^2+\tfrac{1}{2}\,\alpha^2\,Y^2+\tfrac{1}{2}\,Y^2\right]^m\left[-Y^{n-2m}-(\alpha\,Y)^{n-2m}\right]=-A\,Y^n\,\tfrac{1}{2}(\alpha^2-\alpha+1)^m\left[1+\alpha^{n-2m}\right] \quad (4)$$

Similarly, *Circumferential or Diametral Creep.*—

$$C_y=A\,Y^{2m}\,\tfrac{1}{2}(\alpha^2-\alpha+1)^m\left[(Y-\alpha\,Y)^{n-2m}-(-Y)^{n-2m}\right]=A\,Y^n\,\tfrac{1}{2}(\alpha^2-\alpha+1)^m\left[(1-\alpha)^{n-2m}+1\right]. \quad . \quad . \quad (5)$$

*Axial Creep.*—

$$C_z=A\,Y^{2m}\,\tfrac{1}{2}(\alpha^2-\alpha+1)^m\left[(\alpha\,Y)^{n-2m}-(Y-\alpha\,Y)^{n-2m}\right]=A\,Y^n\,\tfrac{1}{2}(\alpha^2-\alpha+1)^m\left[\alpha^{n-2m}-(1-\alpha)^{n-2m}\right]. \quad (6)$$

The case of simple tension is represented by $\alpha=0$, in which case $C_y=A\,Y^n$. In Fig. 3, $A\,Y^n$ is represented by unity ; the curves for $C_x$, $C_y$, and $C_z$ have been derived

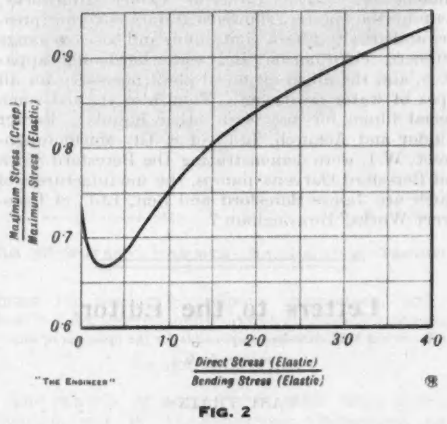



FIG. 2

from the above equations for $C_x$, $C_y$, and $C_z$ with values of $m$ as stated and $n=6$.

In Part II it is shown that all systems of shear stress are embraced by the foregoing relationships for a range of $\alpha$ from 0 to 0·5. It will be seen that in Fig. 3 creep rates between $\alpha=0$ and $\alpha=0{\cdot}5$ are also found in the range $\alpha=0{\cdot}5$ to 1·0 at abscissæ at the same distance from $\alpha=0{\cdot}5$. The axial creep $C_z$ merely changes sign ; the radial creep for values of $\alpha$ from 0 to 0·5 has its counterpart in the circumferential creep for values of $\alpha$ between 0·5 and 1·0 with the sign reversed ; and the circumferential creep $C_y$ for values of $\alpha$ between 0 and 0·5 has similarly its counterpart in the radial creep $C_x$ for values of $\alpha$ between 0·5 and 1·0 with the sign reversed. With the density contant, *i.e.*, $C_x+C_y+C_z=0$, any two of the curves together for the range $\alpha=0$ to $\alpha=0{\cdot}5$ give complete information regarding the behaviour of the material under compound stress.

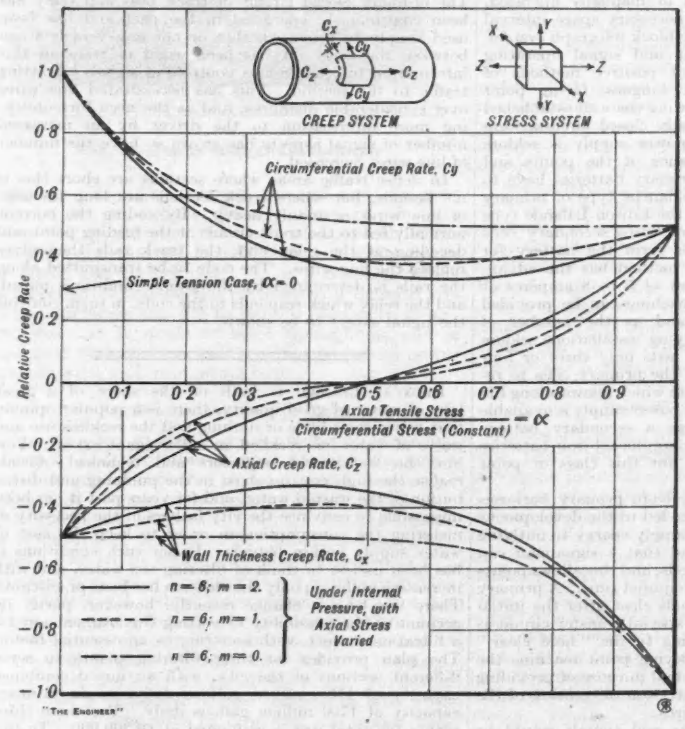

CREEP SYSTEM
STRESS SYSTEM
Circumferential Creep Rate, Cy
Simple Tension Case, α = 0
Axial Creep Rate, Cz
Wall Thickness Creep Rate, Cx
Relative Creep Rate
Axial Tensile Stress / Circumferential Stress (Constant) = α
n = 6; m = 2.
n = 6; m = 1.
n = 6; m = 0.
Under Internal Pressure, with Axial Stress Varied
"The Engineer"

FIG. 3

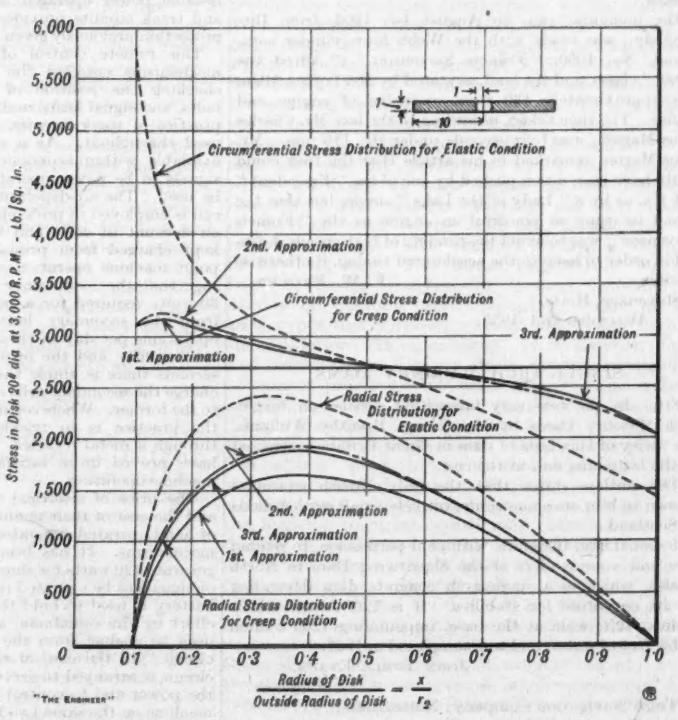

Circumferential Stress Distribution for Elastic Condition
2nd. Approximation
Circumferential Stress Distribution for Creep Condition
3rd. Approximation
1st. Approximation
Radial Stress Distribution for Elastic Condition
2nd. Approximation
3rd. Approximation
1st. Approximation
Radial Stress Distribution for Creep Condition
Stress in Disk 20" dia at 3,000 R.P.M. - lb./Sq. in.
Radius of Disk / Outside Radius of Disk = r/r2
"The Engineer"

FIG. 4

### HOLLOW CYLINDRICAL PARTS UNDER INTERNAL FLUID PRESSURE WITH OR WITHOUT HEAT TRANSMISSION THROUGH THE WALL (*e.g.*, SUPERHEATER TUBES AND PRESSURE VESSELS).

An appendix to the paper analyses the case of a thick cylinder under internal fluid pressure, including the case when there is heat transmission through the wall.

It is shown that in all cases there is no axial creep when the cylinder is under its fluid pressure loading only. Expressions are obtained for the circumferential, radial,

* Institution of Mechanical Engineers, November 22nd.—Abstract.

and axial stresses at any point in the wall, and also for the diametral creep rate. The diametral creep rate is a maximum at the bore, and in view of the importance in design of limiting the maximum creep, especially in the case of steels of high creep resistance, where failure under creep would most probably occur by intercrystalline cracking accompanied by low deformation, it is advisable to regard the diametral creep at the bore as the quantity to be limited by design.

Design needs are satisfied most simply if a working mean hoop stress $f_m$ can be found quickly which would give a diametral creep rate $C_1$ at the bore, equal to the creep rate produced in a simple tensile test by an equivalent stress $f$. The following expression for $\frac{f_m'}{f}$ applicable to all cases is obtained.

$$\frac{f_m}{f}=\left(\frac{4}{3}\right)^{\frac{m}{n}}\frac{n'}{2}\left[\frac{2}{1+(\frac{1}{2})^{n-2m}}\right]^{\frac{1}{n}}\frac{\left(\frac{r_2}{r_1}\right)^{\frac{2}{n'}}-1}{\left(\frac{r_2}{r_1}\right)^{\frac{2}{n'}}\left(\frac{r_2}{r_1}-1\right)}$$

where $r_1$ and $r_2$ are the internal and external radii respectively of the cylinder, and $n'$ is given by $n/(1+\mathrm{H}\,b/4\,\pi\,\mathrm{K})$, K the coefficient of thermal conductivity of the metal, H the heat flow across unit length of the cylinder in unit time, and $b$ a constant defining the dependence of creep rate upon temperature. Taking the values $m=2$, $n=6$ (carbon steel), $n=12$ (18 per cent. Cr : 8 per cent. Ni steel), K=0·0006 B.Th.U. per square inch per degree Fahrenheit temperature difference, per inch thickness, per hour and the temperature drop from tube wall to steam is 35 deg. Fah. The tube wall temperature $\theta_1$ at the inside is 910 deg. Fah.=488 deg. Cent.

At 488 deg. Cent., employing the usual carbon steel and a stress of 1·4 tons per square inch for the case of a simple tension, the left-hand series of curves in Fig. 5 should be employed.

The heat flow H per foot length of tube=$(6000\times 2\,\pi)/12$ =3140 B.Th.U. per hour. The tube is considered as a thin cylinder and $\rho\,(=f_m/f)$ is taken as unity for the first approximation.

*First Approximation.*—

$$\frac{r_2}{r_1}=1+\frac{2000}{1\cdot4\times2240}=1\cdot64.$$

From Fig. 5, $\rho=0\cdot8$, for $\frac{r_2}{r_1}=1\cdot64$ and H=3140,

giving $f_m=0\cdot8\times1\cdot4=1\cdot12$ tons per square inch.

*Second Approximation.*—

$$\frac{r_2}{r_1}=1+\frac{2000}{1\cdot12\times2240}=1\cdot8.$$

From Fig. 5, $\rho=0\cdot75$, for $\frac{r_2}{r_1}=1\cdot8$ and H=3140,

giving $f_m=0\cdot75\times1\cdot4=1\cdot05$ tons per square inch.

A third approximation gives $f_m=1\cdot0$ ton per square inch and a wall thickness of 0·473in., which may be regarded as final figures.

The prohibitive thickness of the tube is due to the comparatively low creep resistance of mild steel at the wall temperatures employed. Replacing mild steel by a molybdenum steel, for which, at 488 deg. Cent., a stress of 4 tons per square inch might be used for simple tension, and using the middle series curves—Fig. 5—gives :

*First Approximation.*—

$$\frac{r_2}{r_1}=1+\frac{2000}{4\times2240}=1\cdot223,\text{ and }\rho=1\cdot02.$$

*Second Approximation.*—

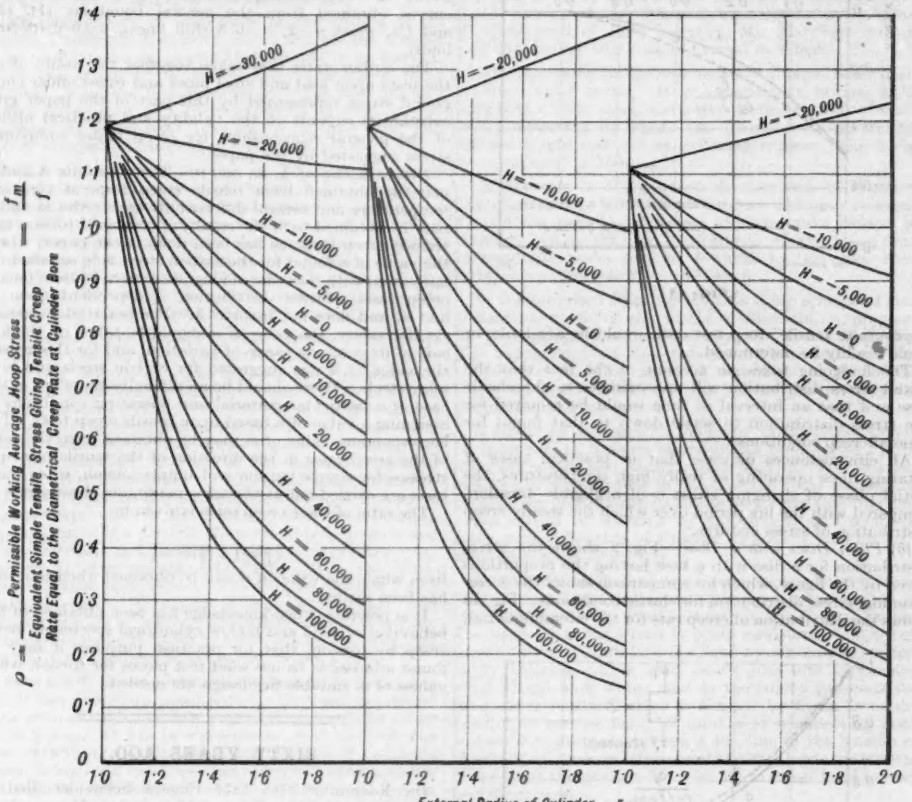
$$\frac{r_2}{r_1}=1\cdot22,\text{ and }\rho=1\cdot025,$$

giving a wall thickness of 0·18in.

Thus the mean stress $f_m=4\cdot1$ ton per square inch may be used for the molybdenum steel. This stress compares with 1·0 ton per square inch for the mild steel and illustrates that for high steam pressures where there is heat flow, a steel of superior creep resistance possesses an added advantage through the smaller permissible wall thickness. In the case of the molybdenum steel the metal temperature at the outside is 914·2 deg. Fah. (490·1 deg. Cent.), compared with 922·6 deg. Fah. (494·8 deg. Cent.) for the mild steel tube.

The behaviour of thin cylinders under internal pressure when subjected either to a bending moment or to a twisting moment has been investigated. In both cases the effect of the fluid pressure loading was found greatly to increase the bending and twisting by creep respectively over that produced by a bending moment or twisting moment acting by itself. Figs. 6 and 7 show the relations obtained for carbon steel.

In the case of steam piping, loading produced by the effects of thermal expansion will generally result in bending and twisting moments being imposed upon the piping. The accelerated creep under these straining actions, when there is also loading by the steam pressure, causes the loading due to thermal expansion to be relieved by creep, and the corresponding stresses are reduced to small and negligible magnitude. The stresses due to thermal expansion when relieved by creep reappear reversed in direction when the system is cold. It is usual for a piping system to be stressed initially when cold in the opposite sense to the stress caused by thermal expansion. Usually this initial stressing is from one-half to two-thirds the calculated stress due to thermal expansion. As a result, the initial thermal stresses at operating temperature would be only one-half to one-third of the values corresponding to the full thermal expansion. In view of the decline in thermal stress that would be caused by creep there appears to be good reason, in the case of piping for high temperatures, to arrange that thermal stresses should have their full value when the system is cold, and therefore from the beginning they would be zero when the system reaches working temperature.




*Carbon Steel, Stress up to 1·5 tons. Carbon Steel, Stress 1·5 to 5 tons. 18 Cr.–8 Ni. Steel.*

FIG. 5

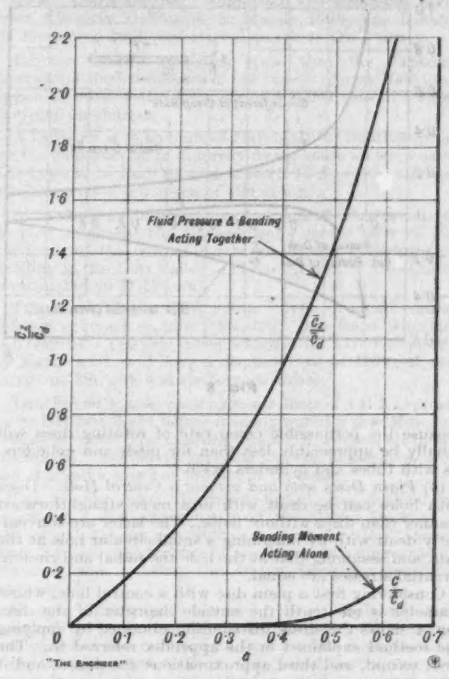



FIG. 6—*Axial Creep.*

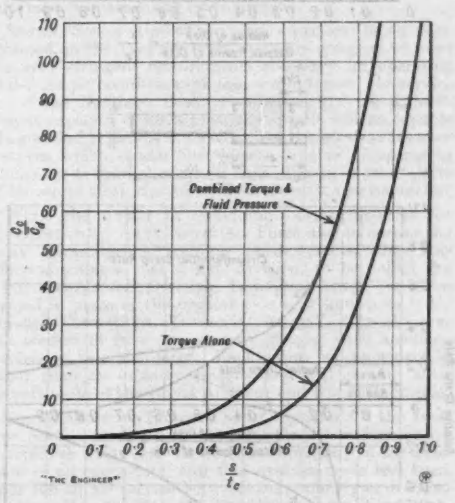



FIG. 7—*Circumferential Creep.*

second for carbon steels and low alloy steels, and a magnitude of 40 per cent. of this value for austenitic steels of the type containing 18 per cent. chromium and 8 per cent. nickel, Fig. 5 has been prepared giving values of $\frac{f_m}{f}$ for carbon steel and 18 Cr : 8 Ni steel in accord with the above expression. In the figure the heat flow H, expressed in B.Th.U. per foot length of cylinder per hour, is positive when the direction of flow is towards the cylinder axis, and negative when it is in the opposite direction.

As the curves of Fig. 5 give the relation between the actual mean hoop stress $f_m$ and the corresponding tensile stress $f$, which in a creep test at the temperature of the metal at the bore would give the same creep rate as the diametral creep rate at the bore, they enable any case to be quickly analysed or designed.

(*a*) *Steam Piping.*—In practice it is unlikely that the ratio of outside diameter to inside diameter would exceed 1·3. It can be seen from Fig. 5 (the curve H=0 for carbon steel is common) that for values of $r_2/r_1$ up to 1·3 the factor $\rho$, or $f_m/f$, is between 1·19 and 1·0. In most cases it would probably range between 1·15 and 1·0. As a general rule, therefore, it would be safe to take $\rho=1\cdot0$. In other words, it will generally be safe, when employing high steam pressures and temperatures, to proportion piping to withstand operating conditions upon the basis of the simple relationship for thin-walled cylinders, and to use a mean tensile stress equal to that given by tensile creep tests for a creep rate or an amount of creep equal to the permissible diametral creep. Where closer and more economic design is needed it would be necessary to employ the curve H=0—Fig. 5.

(*b*) *Tubes, such as Superheater Tubes.*—Tubes are usually employed where there is heat transmission, and in the great majority of cases the direction of heat flow is from the outside to the inside. As an example of the application of Fig. 5 to superheater tubing, the case of tubing 2in. in outside diameter will be considered for steam at 2000 lb. per square inch and 875 deg. Fah., when the heat transmission rate is 6000 B.Th.U. per square foot

in hoop stress, or fluid pressure, equivalent to different ratios of shear stress to hoop stress :—

| | | Ratio of shear stress $s$ due to torque, to hoop stress $t_e$ due to fluid pressure. | | | | |
|---|---|---|---|---|---|---|
| | | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 |
| Ratio of equivalent hoop stress to hoop stress due to fluid pressure | Carbon steel ($m=2$ ; $n=6$) | 1·017 | 1·065 | 1·139 | 1·232 | 1·34 |
| | Lead ($m=3\cdot5$ ; $n=11$) | 1·017 | 1·067 | 1·144 | 1·243 | 1·355 |

## ROTATING DISCS.

Rotating discs have hitherto proved to be a difficult problem to deal with under creep conditions, first—and mainly—because of the insufficient knowledge of creep under compound stress, and second, because of difficulties of rigid mathematical analysis. By applying the general

equations (1), (2), and (3) and employing a method of successive approximation given in an appendix, the distribution of stress in a rotating disc of general cross section can be obtained. From the stress distribution the corresponding diametral, radial, and axial creep rates at any position in the disc are given by the general expressions.

The following cases are given as examples of the results obtained by applying the method. In all cases $m$ has been taken unity, instead of 2, as was done in dealing with cylinders under pressure, in order to be more conservative,

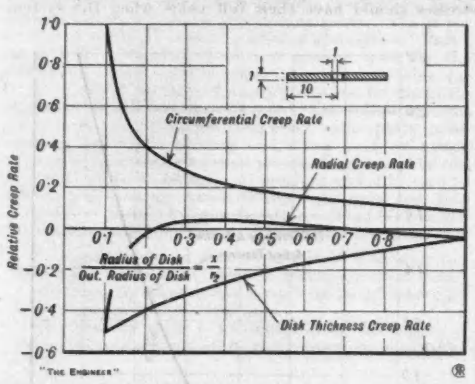
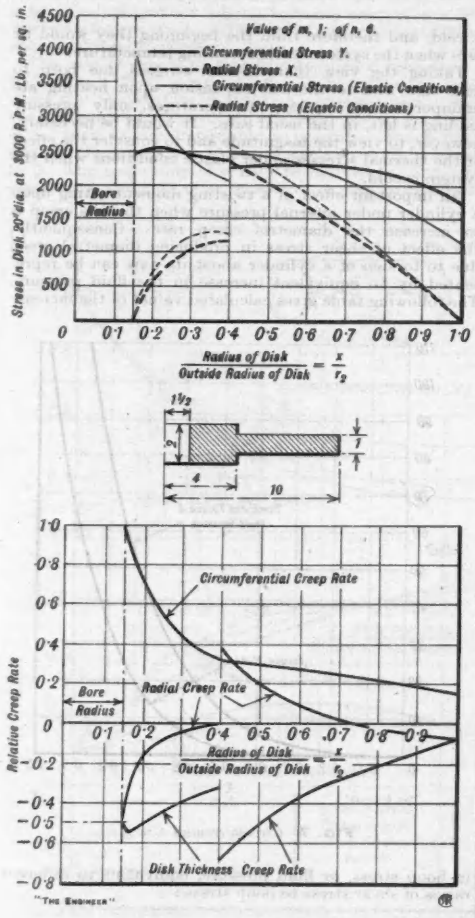

Relative Creep Rate
Circumferential Creep Rate
Radial Creep Rate
Disk Thickness Creep Rate
Radius of Disk / Out. Radius of Disk = x/r2
"The Engineer"

FIG. 8

because the permissible creep rate of rotating discs will usually be appreciably less than for pipes and cylinders. As with tubes and cylinders, $n=6$.

(*a*) *Plain Discs with and without a Central Hole.*—Discs with holes can be dealt with in a more straightforward manner than discs without holes. The latter are conveniently dealt with by imagining a small circular hole at the axis, and assuming that at the hole the radial and circumferential stresses are equal.

Considering first a plain disc with a central hole, whose diameter is one-tenth the outside diameter of the disc, Fig. 4 shows the stress distribution obtained by applying the method explained in the appendix referred to. The first, second, and third approximations are shown, and it


Stress in Disk 20" dia. at 3000 R.P.M. Lb. per sq. in.
Value of m, 1; of n, 6.
Circumferential Stress Y.
Radial Stress X.
Circumferential Stress (Elastic Conditions)
Radial Stress (Elastic Conditions)
Bore Radius
Radius of Disk / Outside Radius of Disk = x/r2
Circumferential Creep Rate
Radial Creep Rate
Disk Thickness Creep Rate
Relative Creep Rate
"The Engineer"

FIGS. 9 AND 10

will be seen that the second approximation is close enough to the third to be sufficiently good for practical purposes, particularly as it errs slightly on the safe side. The diagram gives the stress for a 20in. diameter disc running at 3000 r.p.m. For comparison the distribution of stress under elastic conditions is shown, and it is seen that the circumferential stress at the bore under creep conditions is only 0·52 of the stress which occurs under elastic conditions.

Employing the general expressions for creep under compound stress, the circumferential creep rate $C_y$, the radial creep rate $C_x$, and the axial creep rate $C_z$ have been evaluated and are shown in Fig. 8 in terms of the circumferential creep rate which exists at the bore represented by unity.

Figs. 4 and 8 enable any similar disc to be dealt with. For example, for a disc 24in. in diameter rotating at 2400 r.p.m., the circumferential stress at the bore is $\left(\frac{24\times2400}{20\times3000}\right)^2\times3100=2860$ lb. per square inch. The maximum circumferential or diametral creep rate occurs at the bore and as the stress there is simple tension, the results of tensile creep tests on the material used may be employed directly. For example, with a 0·4 per cent. carbon steel, a stress of 2860 lb. per square inch would only produce a creep of 0·001 strain in 100,000 hours at a temperature of 500 deg. Cent., and the disc would be very safe under these conditions, particularly in view of the fact that the diametral creep rate at the outside of the disc is slightly less than one-tenth of that at the bore. For other magnitudes of permissible creep than that taken,

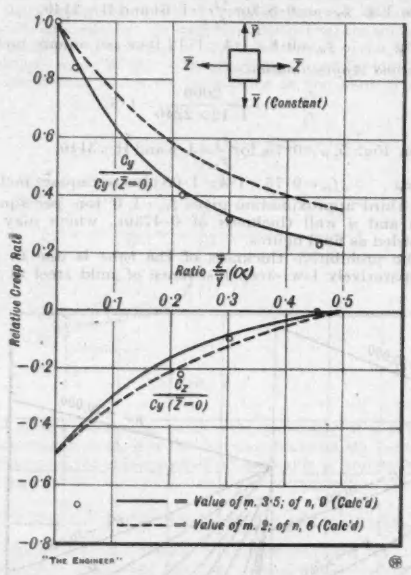

Relative Creep Rate
Ratio Z/Y (α)
Cy / Cy (Z=0)
Cz / Cy (Z=0)
Cx / Cy (Z=0)
Y (Constant)
Value of m, 3·5; of n, 6 (Calc'd)
Value of m, 2; of n, 6 (Calc'd)
"The Engineer"

FIG. 11

appropriate tensile creep test data would be available, or could readily be determined.

The foregoing takes no account of the fact that the initial stress distribution will approximate to the elastic case and that an interval of time would be required for the stress distribution to settle down to that found for general creep conditions.

All circumstances indicate that in practical cases of rotating discs operating at really high temperatures, the initial phase of changing stress is of negligible duration, compared with the life period over which the steady creep distribution of stress endures.

(*b*) *Plain Discs with a Boss.*—Fig. 9 shows the stress distribution for a disc with a boss having the proportions given by the figure, which for comparison shows the corresponding stress distribution for elastic conditions. Fig. 10 shows the distribution of creep rate for the circumferential,

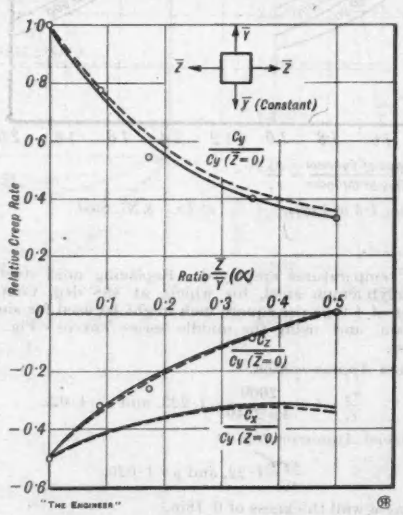



FIG. 12

radial, and axial directions of the disc, with the circumferential or diametral creep rate at the bore represented by unity, as in the case of the plain discs.

For the reasons given in connection with plain discs, the stress in discs with bosses will fall from the initial distribution for elastic conditions to the distribution for steady creep in a period of negligible duration compared with the life of the disc.

### CREEP UNDER COMPOUND STRESS.

Regarding creep as associated with shear stress, the author showed that all systems of shear stress are embraced by (1) the case of a thin cylinder under internal fluid pressure and an axial load producing with the fluid pressure an axial and tensile stress ranging from zero to one-half the hoop stress; or, alternatively, (2) by a thin tube under combined torsion and axial tension covering the range from simple tension to simple torsion. By superimposing a hydrostatic tensile stress system upon the latter, which does not affect the shear stress, the equivalent system of the former type may be obtained.

Utilising test results upon lead pipes under fluid pressure and axial load, the author found reasonable agreement between experimental results and calculated values based upon $m=3\cdot5$ and $n=11$. Using these values the behaviour of a lead pipe under fluid pressure and an axial torque was determined by calculation. Experiment showed results in close agreement with calculation for all three effects of axial creep, diametral creep, and circumferential creep or twist.

Two steel tubes were investigated, one a cold-drawn tube of 0·115 per cent. carbon steel and the other of 0·45 per cent. carbon steel, machined from a solid bar. The former showed evidence of a departure from isotropy which was probably associated with the manufacturing procedure. It was for this reason that the latter was machined from the solid. The results of the creep tests upon the 0·115 per cent. carbon steel tube, plotted to correspond with the case of an equivalent thin cylinder under internal pressure and axial load, or, what is the same thing, under the equivalent shear stress system of two principal tensile stresses $\overline{Y}$ and $\overline{Z}$, as shown by Fig. 11. In these tests $\overline{Y}$ was constant and $\overline{Z}$ ranged between zero and $\frac{1}{2}\overline{Y}$ or $\overline{Z}/\overline{Y}=\alpha$ ranged from zero to 0·5. Simple tension corresponds with $\alpha=0$ and simple torsion with $\alpha=0\cdot5$. Creep rates in Fig. 11 are expressed by their ratios to the tensile creep rate for simple tension, *i.e.*, to $C_y$, when $\overline{Z}=0$. Had the material been isotropic, the curve for $\frac{C_z}{C_y\,(\overline{Z}=0)}$ would have had an ordinate of $-0\cdot5$ for the case of simple tension, whereas it is clear from Fig. 11 that its value was probably in the region of $-0\cdot8$. No such departure from isotropy was shown by the 0·45 per cent. carbon steel tube, as is made clear by Fig. 12, which shows the experimental results plotted together with curves obtained from the general equations (1), (2), and (3), when $n=2$, $n=6\cdot5$ (full lines), $n=6\cdot0$ (dotted lines).

The author states that taken together the results of all the tests upon lead and steel pipes and tubes under compound stress represented by this part of the paper give substantial support to the validity and practical utility of the general relationships for creep under compound stress suggested by the paper.

*Determination of* A, *m, and n.*—The constants A and $n$ may be obtained from tensile creep tests at constant temperature and several different stresses. Also $m$ and $n$ may be obtained to fit the results of combined torsion and tension creep tests, as has been done in the paper, where the value of $n$ found for the carbon steels is in satisfactory agreement with the order of magnitude derived from tensile creep tests. Stress distribution is dependent upon $m$ and $n$, and does not involve A. For practical purposes, *i.e.*, for safety, the value of $n$ should be taken on the low side of its common range of variation, and for this reason the value of 6 was suggested for carbon steels and low-alloy steels. There should be no difficulty therefore in the case of a particular material and operating conditions in assigning a value of $n$ based upon tensile creep tests. The corresponding value of $m$ may be obtained from the ratio of the creep rates in the direction of the tensile principal stresses for simple tension and simple torsion, when these tests are carried out at the same maximum shear stress.

The ratio of these creep rates is given by

$$\frac{2}{(\frac{1}{2})^m[1+(\frac{1}{2})^{n-2m}]}$$

from which the value of $m$ can be obtained when that of $n$ has been settled.

It is possible, when knowledge has been obtained of the behaviour of solid and hollow cylindrical specimens under creep by torsion, that for practical purposes it may be found admissible to use solid test pieces for torsion when values of $m$ suitable for design are needed.

## SIXTY YEARS AGO.

ON November 27th 1875 Eugene Schneider died at his home in Paris at the age of seventy. He was born at Nancy. Little, we said in our issue of December 3rd 1875, was known of his earlier years but by 1830 he was in the position of an ironmaster and comparatively wealthy. His brother, Monsieur A. Schneider, was a banker. Both were men of great energy and resource and together they determined to enter the engineering industry which had already brought fortune and fame to not a few Englishmen. In 1838 the brothers purchased an ironworks at Creusot which had been established in 1782 for the purpose of working the Williams-Wilkinson process of making iron with coke. Under their control the works rapidly became the largest of its kind in France and one of the largest in the world. Within six years the number of workpeople employed had risen to 3000. Later counting the collieries, ironworks and engine factories the number increased to 10,000. In 1845 Monsieur A. Schneider died as the result of an accident. Eugene Schneider mourned his loss but did not pause in his endeavour to make the Creusot works celebrated throughout the world. A proud moment in his life came in 1865 when he received an order for forty fast passenger engines from the Great Eastern Railway. For that order he underbid his English competitors and guaranteed delivery in less time than any English firm. The dispute between his firm and Nasmyth as to who was the inventor of the steam hammer has passed into engineering history. It would appear that in 1842 Nasmyth visited Creusot and there saw a somewhat clumsy arrangement for forging iron by steam power. In April of that year the Schneider hammer was patented in this country. Nasmyth's patent was taken out in June of the same year. Little more was heard of the Creusot hammer for it was crude as compared with Nasmyth's which soon became popular. Actually both had been anticipated by James Watt who patented a hammer worked by steam in 1784. Eugene Schneider took an active part in the political side of French life. He was an ardent supporter of the Emperor Napoleon the Third and in 1851 was appointed Minister of Commerce and Agriculture. After the *coup d'état* which gave Napoleon the Emperor's throne, Schneider was appointed vice-president of the Corps Législatif. He loved peace because only in peace could prosperity be found. It was his fate to live in times when France knew little peace and he died during a period of inquietude and uncertainty concerning the country's future.

## Rail and Road.

THE experiment of railing off pavements at dangerous junctions has met, it is believed, with a fair amount of success in regulating the streams of traffic, but the proposal to place continuous railings along a length of 3 miles at Stepney is held by the Pedestrians' Association to call for the most careful consideration.

WE are informed by Sir William Arrol and Co., Ltd., that when the landslide near Winchfield, Hants, occurred on the morning of Sunday, November 17th, the Southern Railway communicated with them and they had plant working on the site the following afternoon. They soon had four Ruston mechanical excavators clearing the track and shifting the fall of earth.

THE approach of the end of the railway year makes the table of traffic receipts of interest. At the close of the forty-sixth week each main line company reported increases, as compared with the corresponding period of 1934, as follows:—L.M.S., £665,000, or 1·25 per cent.; L.N.E., £103,000, or 0·26 per cent.; G.W.R., £189,000, or 0·85 per cent.; Southern, £185,000, or 1·03 per cent.

IT is said to be the intention of the Government to get the Bill, by which the railways' £30,000,000 development scheme is to be assisted, passed before Christmas. A special finance corporation will be formed to raise, with a Government guarantee, about £26,000,000 of the capital required, the balance being found by the main line railway companies. The arrangements will be similar to those adopted in the London Transport scheme.

THE introduction of trollybuses on the system of the London Passenger Transport Board led to the request of the men's trades union that there should be an increase in the rates of pay of the drivers and conductors of those vehicles. After the usual procedure it has been decided to give these men and the corresponding men on the tramways an immediate advance of 2s. per week and another increase of a similar amount next October.

THERE was a further meeting on Tuesday, November 26th, of the representatives of the main line companies and of the three railway trades unions as to the application of the latter for the complete withdrawal of the wages cuts. The representatives of the companies explained the present economic position of the railway industry and submitted statistics. The representatives of the unions said they would like time to examine the figures, and the meeting, which lasted 2½ hours, was adjourned.

THE usual Parliamentary Notices of the intentions of each of the four main line companies to apply for powers for the carrying out of works in the present session were published on Monday, December 2nd. The L.N.E.R. intends to widen certain portions of line in the Newmarket area, and on the main line to the North. A separate Bill is to be presented for the works required in connection with the company's interests in the London Passenger Transport Board's scheme, for which authority to borrow £10,000,000 from the London Electric Passenger Transport Finance Corporation is also needed. The Great Western proposals cover the Dawlish-Newton Abbot by-pass and the St. Germans and Looe new railway. Alterations are proposed at Marlborough, which will allow the Marlborough branch to be closed. The company's share in the London Passenger Transport scheme is mentioned and authority sought to borrow £2,000,000. No new railway is intended to be constructed by the Southern Railway, and apparently no Bill is to be deposited by the L.M.S.

AFTER the Wormley level crossing disaster of November 27th of last year, two passengers by the train concerned in the accident related their experiences in a joint letter to *The Times*. It will be remembered that this was one of an unfortunately relatively large number of accidents at occupation level crossings, and happened when a motor road vehicle, crossing the railway, was struck by an express passenger train which was derailed and the driver and fireman killed. The accident was inquired into by Colonel Trench, whose report was issued on January 21st last and reviewed in THE ENGINEER of February 15th. In *The Times* of November 30th appeared another communication, signed by the same two passengers, protesting that nothing, visible to them, has been done to remove the danger of "four completely unguarded crossings being used, without let or hindrance, by heavy industrial traffic, at which every express train is at the mercy of any careless or foolhardy lorry driver." We would once again remark that this, from a legal point of view, is a very simple matter. Occupation crossings are a compulsory provision for the convenience of a landowner whose property becomes separated by the building of a railway. The responsibility of the user of the crossing then lies with the landowner. On the other hand, a certain moral responsibility lies with the railway to avoid accidents.

TWENTY-FIVE years ago there were three serious railway accidents, all due to signalmen overlooking trains and engines standing at or near their signal-box and admitting another train into the same section. The first of these three accidents occurred at Willesden, L. and N.W. Railway, on December 5th, 1910. Two trains from Watford, both filled with businessmen, were concerned. The first stood in the station in such a position that it could not be seen from the signal-box. At that time the signalman had occasion to use a disc signal coupled to No. 53 lever. He said that by accident he pulled No. 55 and so lowered the home signal and admitted the second train. There was a doubt as to whether the man made such a mistake, but Sir Arthur Yorke pointed out that the accident, in which five passengers lost their lives, could not have happened had track circuit been installed. The general use of that safeguard, he pointed out, would, however, necessitate the bonding of the Mansell wheels. There was some serious telescoping, and that subject also received attention at the hands of the inspecting officer. A matter of general interest was referred to as follows:—"It is often urged that safety of working would be increased if two men were always employed in a signal-box. This idea is not confirmed by the present occurrence, as there were two experienced signalmen in the box and yet the mistake occurred. It is by no means improbable that the division of responsibility between the two men was in some way or other the cause of the accident."

## Miscellanea.

THE first pump to serve petrol made from British coal was formally opened for service on Friday, November 29th, at the station of Brew Bros., Ltd., in Kensington.

A TUNNEL 10 miles long has recently been put into service at Sydney to carry the city's water supply. This tunnel, which has taken fourteen years to build, cost some £2,500,000.

CORROSION tests on iron, galvanised under various conditions in water saturated with oxygen, show that the best corrosion resistance is obtained by coatings deposited slowly at low current density.

THE Dalmarnock power station of the Glasgow Corporation is to be extended. Two 50,000-kW turbo-generators costing £353,770 and steam generating plant costing £491,045 have been ordered.

A NEW way of presenting papers was adopted by the American Society of Naval Architects and Marine Engineers recently. The authors presented their various papers by reading an abstract of not more than 200 words.

A NEW factory for the manufacture of nails and screws is to be built at Limerick. It is stated that it will be protected by an *ad valorem* duty of 75 per cent., which will virtually give the new establishment a monopoly of the Free State market.

THE appointment has been announced of Sir Angus Newton Scott as Chairman of the Royal Commission on Local Government on Tyneside, in succession to Sir Sidney Rowlatt, and of Lord Merthyr, Mr. Harrison Barrow, and Mr. George Clark as additional members.

AN interesting bridge was recently completed in Idaho in the United States. It is a suspension bridge, 327ft. long with a 240ft. span, and is constructed entirely of wood, being supported by eight 1¼in. diameter cables and the wooden guard rails act as stiffening trusses. The bridge has a capacity of 16 tons.

ACCORDING to a report of the Division of Research Information of the United States National Research Council on petrol losses from storage tanks caused by radiation from the sun, two-thirds of the losses from unprotected tanks can be avoided by covering them with aluminium paint or whitewash.

IT is announced from Agram that a big scheme of electrification, covering the whole of Slovenia, is proposed by the Ljubljana authorities, says the *Electrical Review*. The expenditure on long-distance transmission lines and transformer stations alone is estimated at 70,000,000 dinar, while the local networks will be provided by the communes and industries.

A CIRCULAR dealing with the plant for the production of oil from coal at Seaham Harbour has been issued by the directors of Coal and Allied Industries, Ltd. It states that twenty-six ovens, equal to one-half the total carbonising battery, are now in continuous operation and that fifty-one ovens should be working by the middle of December. Each oven is capable of treating 2¾ tons of coal and the same amount of oil per day.

AN unusual method of muck removal has been successfully adopted by contractors driving a sewer tunnel in the Minneapolis–St. Paul district in the United States. The tunnel is being driven in white sandstone rock, which is easily broken down into fine sand by air chisels, spades, or by blasting. This sand easily goes into suspension when mixed with water, and as the tunnel proceeds the sand-water mixture which is flushed by hoses from the heading is carried back by ditches to a collecting pool, whence it is pumped through a 4in. line to the bottom of the shaft, a maximum distance of 3600ft. From the bottom of the shaft the mixture is forced up to street level by two booster pumps.

SPEAKING at the annual meeting of R. A. Lister and Co., Ltd., the chairman said that during the past year the company had carried out extensive tests and developments in connection with the application of chrome hardening to wearing parts of their oil engines, particularly cylinders and cylinder liners, and so satisfactory had been the results of these tests to date that they had built and equipped suitable shops for production, and they believed that their association with this pioneer work might bring the process to the fore, not only in the compression-ignition engine industry, but in the aeronautical, automotive and marine engineering industries as well, with possibly far-reaching results.

A GRAIN elevator with a capacity of two million bushels has been constructed in Toronto in the short time of eleven weeks. The work involved the driving of 4700 timber foundation piles, the placing of 1600 cubic yards of concrete, and the installation of extensive conveying equipment. The new structure comprises forty circular tanks arranged in four rows of ten each with twenty-seven interspacial bins, the whole occupying a ground area of 249ft. by 100ft. It is carried on a 4ft. thick reinforced concrete mat capping a foundation of 4700 round timber bearing piles. The tanks, which are of reinforced concrete, 24ft. in diameter with a wall thickness of 7in., take their rise from the top of the mat and extend to a height of 135ft.

A RAILWAY company in the United States has adopted on certain sections a solid continuous reinforced concrete track bed, in which the rails are embedded in the concrete, thus dispensing with the use of sleepers. The track bed consists of continuous slabs of concrete, reinforced with ¼in. square steel bars, the slabs being 8ft. wide and 18in. deep. The reinforcing bars are spaced 12in. in each direction in a plane 3in. from the bottom of the slab. The transverse reinforcement has every second bar bent up between rails to take the negative bending moment, and to provide added resistance to shear. When parallel tracks are concreted, the 8ft. slabs are placed separately at grades and levels determined by the track requirements. This method of track construction is particularly suitable for railway sections which cross streets—indeed, for the street crossing this form of construction has a lower first cost than other types. Maintenance cost is practically nil.

## Air and Water.

A TWICE-WEEKLY air service between Glasgow and Skye has been started.

A MOTOR coasting vessel, 104ft. long and of 260 tons, was recently launched broadside on at Faversham, in Kent.

IT is reported that a new aerodrome is to be built near Ismailia, 100 acres having been assigned to the Civil Aviation Department for its construction.

THE "China Clipper" completed the inaugural flight from Alameda, California, to Manila, Philippine Islands, on November 29th, and started on the return journey.

RECENT official statistics state that the Japanese Mercantile Marine consists of 841 vessels of over 1000 tons. Japanese owners also have about 500,000 tons of foreign shipping on charter.

A FACTORY is to be built at Hamble, near Southampton, for the construction of Sikorsky flying boats under licence. The type to be built at first is the S 42 A, a 32-passenger machine with a top speed of 190 m.p.h.

AT a meeting of the Ouse Catchment Board, it was decided to accept the Government's recent offer of 33⅓ per cent. of the cost of a scheme for the preventing of flooding in the Don Valley. The total cost of the scheme is estimated at £1,190,000.

THE ninth of the "Swordfish" type of small coastal defence submarines, the "Seawolf," has been launched at Greenock. The new vessel, which is due to be completed by March next, will have a displacement of 670 tons and carry one 3in. gun and six torpedo tubes.

THE Soviet's new passenger air liner Z.I.G.2 crashed on its last test flight before it inaugurated a new Moscow-Prague service. The machine was a low-winged, all-metal monoplane, capable of carrying twelve passengers, and had attained a speed of 195 m.p.h. on trials.

THE Southampton Harbour Board has decided to undertake a dredging scheme off the Ocean Dock at a cost of £17,500, to give sufficient room for the "Queen Mary" to be manœuvred in the lower swinging ground whenever she is using the Ocean Dock for berthing purposes.

A NEW fishing patrol vessel, the "Vigilant," was launched on December 3rd at Dumbarton. This is the first vessel of the new programme for the strengthening of the fishing protection fleet. The vessel has twin screws driven by oil engines of 1500 h.p., and in appearance resembles a trawler, but has a speed and cruising range much in excess of that class of ship.

OWING to disturbances in Brazil the "Graf Zeppelin" was recently unable to land at the mooring mast near Pernambuco, and it created a new record by remaining in the air for 119 hours. During this period the airship took food supplies from a steamer and remained cruising off the coast. This was the 500th voyage of the airship and the previous record for duration was 111 hours in the air in October, 1928.

As a result of three years' preparatory work by Soviet navigators, it is reported in the *Shipping World* that cargo vessels have this summer established a route to the Far East along the northern coasts of Europe and Asia. An ice breaker fleet placed along the route has kept the channels open. More than a hundred ships of the Soviet mercantile marine have this year passed along this route without a single mishap. Five radio stations keep vessels informed of weather and ice conditions.

SEVEN Soviet timber-carrying steamers being constructed on the Tees are being specially designed to meet the very stringent requirements necessary for operating under Arctic conditions, as they are intended for service round the Northern Coast of Siberia. Having a deadweight capacity of 4000 tons, the vessels will be capable of a speed of 11½ knots in service. The design also embodies features which render the vessels capable of operating efficiently as general cargo or bulk carriers in other parts of the world when the Arctic Seas are no longer navigable.

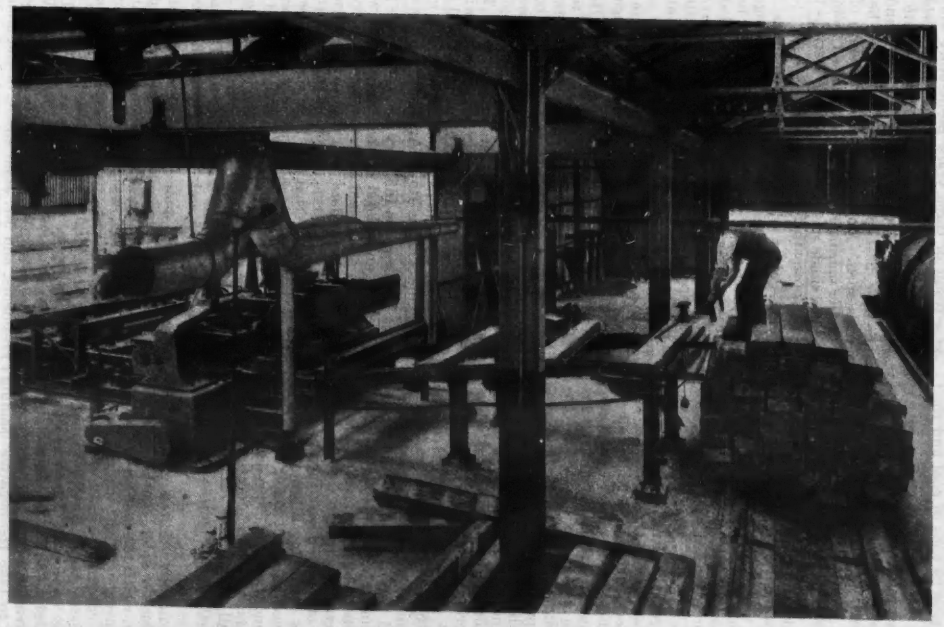
WITH the object of providing better facilities for co-operation with the Royal Air Force and to ensure the most advantageous training arrangements, the War Office announces that a new division, to be called the "1st Anti-Aircraft Division, Territorial Army," is to be formed in place of the organisation now known as "Air Defence Formations, Territorial Army." The division will consist of four anti-aircraft groups, with ancillary services to be added later. Each group will be generally larger than an infantry brigade and will contain anti-aircraft units of the Royal Artillery and Royal Engineers.

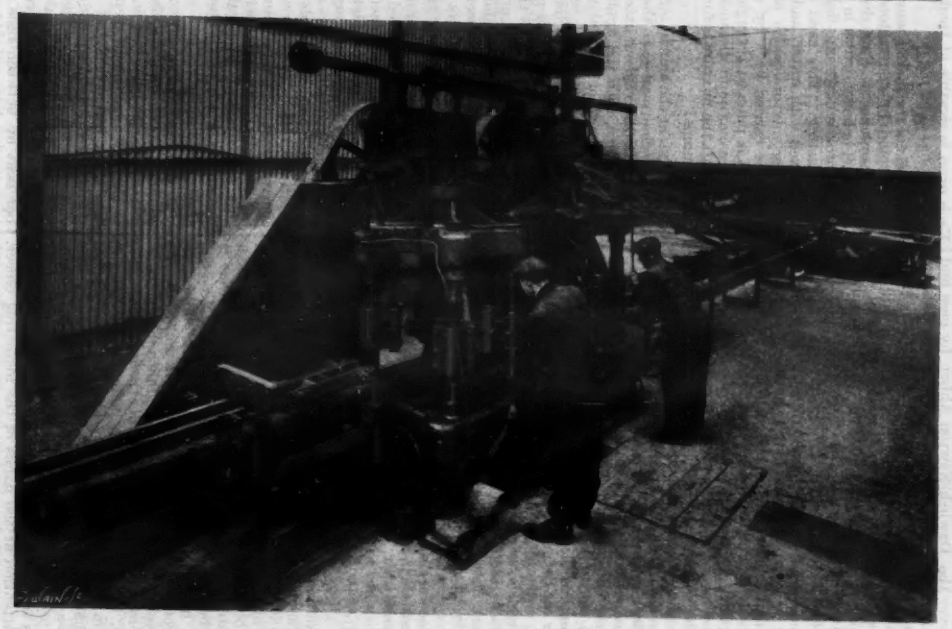
THE Minister for Industry and Commerce for the Irish Free State announced in the Dail that it was proposed to establish a national air transport company in the Free State at an early date, and that arrangements had been made for an air service between that country and Great Britain. He said that the Free State cross-Channel air service would be operated strictly on commercial lines. The first services to be established would be between Dublin and Liverpool, and Dublin and Bristol, connecting with the fast express trains serving those ports. After a little time, through services between Dublin and London and perhaps Cork and London would be established.

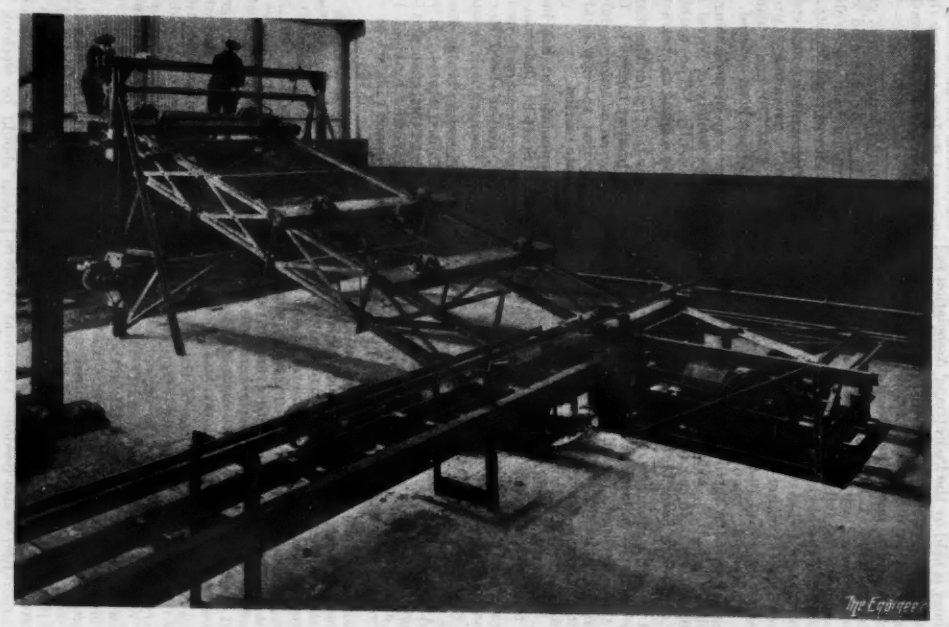
AT the recent annual general meeting of the Central Board of the Shipbuilding Employers' Federation, Mr. Maurice E. Denny, of William Denny and Brothers, Ltd., Dumbarton, was elected President for the ensuing year, in succession to Mr. Charles S. Swan, of Swan, Hunter and Wigham Richardson, Ltd., Wallsend. Mr. F. E. Rebbeck, of Harland and Wolff, Ltd., Belfast, Glasgow, &c., and Mr. F. C. Pyman, of William Gray and Co., Ltd., West Hartlepool, were re-elected Vice-Presidents, and Mr. John Elliot, of the Mountstuart Dry Docks, Ltd., Cardiff, was elected Junior Vice-President to fill the vacancy caused by the election of Mr. Denny to the presidency. Mr. J. A. Pearson, of Scotts' Shipbuilding and Engineering Company, Ltd., Greenock, was appointed Chairman of the Conference and Works Board of the Federation, with Mr. J. W. Tocher, of the Wallsend Slipway and Engineering Company, Ltd., Wallsend-on-Tyne, as Vice-Chairman.

# GREAT WESTERN RAILWAY: SLEEPER CREOSOTING DEPOT AT HAYES, MIDDLESEX

(For description see page 600.)







ABOVE:—ADZING AND BORING MACHINE
BELOW:—CHAIRING MACHINE

ABOVE:—BOLTING BENCH AND CHAIR CONVEYOR
BELOW:—DESPATCHING CONVEYOR AND ELEVATOR

# The Engineer

*DECEMBER 6, 1935.*

VOL. CLX. No. 4169


## Contents.


THE ENGINEER, December 6th, 1935. PAGE

A SEVEN-DAY JOURNAL ... 583
MECHANICAL FLOW METERS. No. II. (Illus.) ... 584
THE PUBLIC WORKS, ROADS AND TRANSPORT EXHIBITION. No. IV. (Illus.) ... 586
LETTERS TO THE EDITOR—
Fast Trains ... 591
Single-arch Masonry Dams ... 591
Domestic Refuse Disposal ... 591
Joints in Concrete Paving ... 591
Power for Nothing ... 591
MODERN DEVELOPMENTS IN RAILWAY SIGNALLING ... 591
UTILISATION OF CREEP TEST DATA IN ENGINEERING DESIGN. (Illus.) ... 592
SIXTY YEARS AGO ... 594
RAIL AND ROAD ... 595
MISCELLANEA ... 595
AIR AND WATER ... 595
LEADING ARTICLES—
The National Consumption of Coal ... 597
Geared Locomotives ... 597
BODY MECHANISM AND ENERGY ... 598
PROBLEMS OF RIVER POLLUTION ... 599
LITERATURE ... 599
BOOKS RECEIVED ... 599
NEW G.W.R. SLEEPER CREOSOTING DEPOT. (Illus.) ... 600
THE GEARED LOCOMOTIVE ... 602
BRITISH OXYGEN COMPANY'S NEW WORKS. (Illus.) ... 602
A SHIP'S EMERGENCY GENERATING SET. (Illus.) ... 603
A ROPEWAY EXTENSION FRAME. (Illus.) ... 603
STREET SURFACE BRIGHTNESS METER. (Illus.) ... 603
PROGRESS OF FUEL RESEARCH ... 604
THE DEVELOPMENT OF COAL HYDROGENATION. (Illus.) ... 604
CONTRACTS AND ORDERS ... 604
CATALOGUES ... 604
ELECTRICAL UNITS ... 606
PERSONAL AND BUSINESS ANNOUNCEMENTS ... 606
MARKETS, NOTES AND NEWS ... 607
CURRENT PRICES FOR METALS AND FUELS ... 608
FRENCH ENGINEERING NOTES ... 609
BRITISH PATENT SPECIFICATIONS. (Illus.) ... 609
FORTHCOMING ENGAGEMENTS ... 610


### NOTICES TO READERS.

**** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

**** *For Subscription rates, see page 2 of Advertisements.*

**** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

**** *Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

## THE NATIONAL CONSUMPTION OF COAL.

IN 1769 Watt patented his invention of the surface condenser. Up to that date the country's coal requirements had been met by the working of outcrops or by mining operations which consisted of little more than scratching the surface of the earth. Slowly at first but soon with increasing momentum, the industrial expansion which followed Watt's invention intensified the demand for coal. Before a hundred years had passed many men were anxiously asking themselves how long the country's coal resources would last in face of the ever-growing drain upon them. The mid-Victorian era, as we now know to our cost in several directions, was not a period characterised by an over-display of consideration for the welfare of the generations to come. On the subject of coal and the exhaustion of supplies genuine anxiety was, however, expressed by many thinking people. It provided the topic of numerous grave lectures and was studied by more than one Royal Commission or Select Committee. The gloomier people piled figure upon figure to prove that within a measurable time this country would be bereft of coal and would have sunk "to the level of a mild and populous Norway or Holland." Others, less gloomy, gave the mines a longer life but argued that the working out of the best seams and the rise in the cost of coal resulting from our having to mine it at greater depths would soon place our industries at a serious disadvantage relatively to those of other countries which had begun the intensive exploitation of their coal resources at a later date. Naturally there were some people who refused to be in any way depressed by the visions of the prophets. They argued that long before our coal supplies were exhausted, man would have invented some other source of power. Gaily they hailed the infant electricity as providing the promise of such a source. In vain were they told that electricity could no more be created than heat and that its use would involve the same recourse to our accumulated stores. Contrasting the picture as it is actually presented to us to-day with what the prophets of sixty and seventy years ago thought it might be, we have to note that the fears expressed by one side, rationally founded though they may have been, show no signs of being fulfilled, while the light-hearted optimism of the other side, irrational as it was in detail, has largely been justified. A new source of thermal energy has been found in oil. So far are the mines from being exhausted that a powerful association has been established for the sole purpose of inducing people to consume more coal.

That the waste of coal in the production of power and heat must have been great in those days is clear from our knowledge of the improvements in its economical use which have since been introduced. Detailed contemporary figures for the efficiency of steam power plant and for the consumption of fuel in metallurgical processes fully support this conclusion. A broad survey of the situation as it then presented itself to a very acute observer is to be found in the address "On Fuel" which Mr. C. W. (Sir William) Siemens delivered at the Bradford meeting of the British Association in 1873. Of the 105 million tons of coal consumed in this country during the preceding year, no less than 50 million tons might, in Sir William's opinion, have been saved by careful and judicious use. That saving, he added, could not be made quickly or without a large expenditure of capital but that it was practicable he had no doubt. It would appear that his estimate of what might be saved was based on an existing average efficiency in the consumption of coal of about 10 per cent. and upon the possibility—a reasonable one in all the circumstances—of increasing this figure to 20 per cent. At that time, according to Sir William, our necessities for the effects of heat were increasing at the rate of 10 per cent. per annum. Our coal consumption, however, was increasing at the rate of only 4 per cent. The balance of 6 per cent. was being provided by what Sir William called our intellectual progress, that is to say, presumably, by the improvements effected in the economical consumption of coal. He was not satisfied with a position which involved an annual deficit of four million tons to be met by increased coal consumption. He maintained that our intellectual progress should be brought up to the rate of our industrial progress by which means the production of coal would be made nearly a constant quantity for several generations to come. The recently published report for 1935 of the Fuel Research Board tells us how we are faring in this direction. In 1910, the report says, our population of 41 millions consumed 180 million tons of coal. In 1934 with a population of 45 millions we used only 161 million tons. On their face these figures would imply that our intellectual progress has not only kept pace with, but has considerably outrun, our industrial progress. That is not only the facial but the actual interpretation which the report places upon the figures. In support of its interpretation the Board gives statistics illustrating the improved efficiency realised in three major coal-consuming industries. If the efficiency of generation had remained the same in 1934 as it was in 1910 the country's electricity undertakings would last year have used 17½ million tons of coal more than they did actually consume. On a similar basis the gas industry would have used nearly 8 million tons of coal more than it did and the coke-oven industry about 6 million tons more. These three industries alone have thus, apparently, in the course of twenty-five years increased the efficiency of their operations to an extent which last year resulted in an aggregate saving of some 31 million tons of coal.

At first sight, as we have said, the Fuel Research Board's figures appear to imply that we have reached the state described by Sir William Siemens in which our "intellectual progress" is abreast of our "industrial progress." The increasing use of oil as fuel in substitution for coal must, however, be taken into account. It has provided the new source of power which the mid-Victorian optimists anticipated. What proportion of the reduction in the total annual consumption of coal is attributable to its replacement by oil it is impossible to say but from a knowledge of the amount of oil imported into this country it is safe to state that without oil the coal consumption would have been much greater. So far as the electricity and gas industries are concerned, however, we can leave the upsetting effect of oil out of account. In 1933 the total oil fuel used in generating stations, either in oil engines or under oil-fired boilers, amounted to 35,000 tons. The total quantity of coal or coke used in steam stations reached over 9 million tons. In the gas industry oil-gas is now frequently produced to supplement the coal gas but the quantity of oil so consumed is very small relatively to the quantity of coal used. We may therefore take these two industries as being substantially unaffected by the advent of oil as a fuel alternative to coal. A brief examination of the figures given in the Board's report—summarised elsewhere in this issue—will show that in neither case has the efficiency been increased during the past twenty-five years at the rate required to keep pace with the increased demand for the product of the industry. The demand for electricity has increased since 1910 in the ratio of about 6½ to 1; the efficiency of electricity generation has been increased over the same period in the ratio of 2½ to 1. The gas industry is in somewhat better case. The demand for gas has increased in the ratio of 1·66 to 1; the efficiency of gas generation has been increased in the ratio of 1·46 to 1. Both industries are therefore meeting the demand thrown upon them by "industrial progress" partly by their "intellectual progress," and partly by increasing their demand on the mines. Were Sir William Siemens alive to-day he would no doubt be surprised to find that these two representative industries have still some way to go before they reach his ideal state. Whether they will ever reach it we may well doubt for with each year and with each improvement of efficiency the opportunity for further improvement lessens.

### Geared Locomotives.

AN article by a correspondent on "Geared Locomotives" will interest all running-shed men. To have suggested the employment of geared steam locomotives for main line duties would, a few years ago, have been to court ridicule. But the gearing of to-day is very different from the gearing of yesterday, and on mechanical grounds there is less objection to using it on a steam engine than on an internal combustion engine. There are, in fact, in existence many geared steam locomotives for special services, and a few, which may still be regarded as experimental, on normal services. Amongst the latter we include the few steam turbine engines now in use. With the turbine the employment of a reducing gear of some kind is imperative. It must have a high ratio, and a reversing gear may be incorporated with it. The gear envisaged by our author is simpler in one respect, but more complicated in another. He does not say so, but we assume that he proposes to use a fairly high-speed engine, making, say, 600 revolutions per minute against the 300 or so that are now usual on passenger engines. Hence the maximum gear would have a very low ratio and a relatively low speed. That is in its favour; but, on the other hand, it is proposed to give the gear three ratios so that one class of engine may be suitable for express passenger, intermediate, and slow trains.

Our author, who is, it will be divined, an experienced railway man, makes his points with some cleverness, but we doubt if in actual practice his scheme, either from the constructional or the service aspect, would work out so simply as it seems to do when presented in words. Consider the former. The first difficulty is to find room for the gear-box. Here we must make a few assumptions. Let us take a two-speed unit having the ingoing and outgoing shafts in the same straight line. It is to transmit 2000 h.p. from a primary speed of 1000 r.p.m. to a secondary speed of 384 or 625 r.p.m. With the ingoing shaft speed reduced to 600 r.p.m. output speeds of 230 or 375 r.p.m. would be available. These alternatives may be not quite what our author has in mind, but they are sufficiently near to the practical requirements for our present purpose. Now, we are informed by an eminent gear designer that the length of the unit, exclusive of shaft extensions, would be 5ft., that it would be over 4ft. wide, and not less than 2ft. in height; its approximate weight would be a ton and a half. It would not be impossible, perhaps, but it would certainly be difficult, to accommodate it on one of the driving axles, where it must obviously be placed. It is true that there would be some saving in weight by increasing the speed of the engine, but it seems not at all improbable that, whatever arrangement was made, the total weight would be greater than before, and the distribution of it might present difficulties. The gear would, of course, have to be provided with change mechanism, but we take it that our author intends the change to be made in the running shed to suit the service on which the engine is going at the time. It might therefore be of a relatively simple kind. No reversing gear would be needed, the engine being reversed and controlled in the usual way. Leaving the gear-box,

we come to another item of great importance—the boiler. Our author passes over it very lightly. He speaks of "ample capacity," but does not discuss the fact that what might be ample for certain services would be excessive for others. Hence a quite unnecessarily large and heavy locomotive might sometimes be used, with bad economic results. That difficulty could, of course, be got over by having several sizes of engines, each of which would be adaptable by gear changing to any one of these services. But would not that bring us back very nearly to our starting point? One final point calls for attention. Our author speaks of the greater evenness of the turning moment in gear-driven engines. Here, we fear, he has inadvertently dropped into an error, unless we have entirely misunderstood the type of engine he has in mind. Clearly variations in the crank effort must be transmitted through the gearing. If at certain speeds the ratio between engine revolutions and wheel revolutions was only 2 : 1, then the best that could be attained would be no more than a reduction of the maximum efforts to one-half. By using a very high-speed engine and, consequently, a high-ratio gear, greater smoothing could be effected. But we do not think our author has such an engine in mind. In any case, it is an interesting question whether many small variations in the turning moments at the wheel rim are less injurious to the rail than fewer larger variations.

There is no single factor in the normal steam locomotive which has made it persist unchanged in fundamentals throughout a century than its simplicity. Of all steam engines it does that which it has to do with the greatest directness and with the least multiplication of parts. To this simplicity it owes its reliability under conditions which would severely try more complex mechanism. Through this simplicity it is able to hold its place with a low thermal efficiency against more efficient but complex designs, for it gains from this single characteristic more than it loses in the cost of coal consumed. Many and many different designs have been advanced, and many have been tried; but always the steam locomotive has come back to the elementals settled by the genius of Stephenson a hundred years ago. That is not because locomotive engineers the world over are unprogressive and prejudiced, but because experience has taught them, and with each new attempt still teaches them, that, taken all in all, the direct-acting locomotive gives better service and, everything considered, greater economy than any alternative forms. Our correspondent's proposal would involve a departure from this simplicity, and whilst it has, inherently, certain attractions, we feel sure that it is unlikely to find favour on the great European railways, whilst admitting that on lesser lines, particularly overseas, its advantages might outweigh its drawbacks.

# Body Mechanism and Energy.*

By Professor A. V. HILL, Sc.D., M.D., &c.

THERE are reasons, and good ones, why a physiologist should feel at home in the company of engineers. First, engineers, like physiologists, place no undue trust in theory. Theory is an essential guide to good experiment, a necessary means of correlating the results of experiment, the background of the subsidiary sciences (as we regard them) on which our own is built up; but the practical situations with which both of us have to deal are often too complex for purely theoretical treatment, we are forced to trust to experience and intuition, we prefer to see the experiment made. Second, engineers, like physiologists, are concerned with systems which "function," or should "function," which are designed (or apparently designed) for a purpose. Members fit into each other, there are integration and organisation between the several parts; a good machine shows almost vital qualities in its fitness to go on working, often for long periods.

A great American physiologist has discussed the fitness of the environment for living systems; had it not been for so many apparent chances in the fundamental nature of things, for example, in the properties of water and of carbon dioxide, life—in any sense that we know it—would have been impossible. One gathers the same impression of engineering. The properties of water and steam, the existence of lubricants and alloys, the possibility of steel springs, the occurrence both of very perfect electrical insulators and of good conductors, even the concentration of oxygen in the atmosphere, all have a very fundamental bearing on your subject. In various adventures with instruments I have continually realised that many devices are not really invented; they seem to be inherent in the nature of things; they are there, so to say, ready to use, only waiting to be discovered. The Architect of the Universe designed not only the machines themselves, but the possibility of machines. Just as He invented not only living things, but the inherent physical characteristics of the environment which made those practicable.

A third and very practical reason for co-operation between physiologists and engineers is that engineers have to design and manufacture things for human use. The most elementary machines, *e.g.*, spades, scythes, knives, screwdrivers, not to mention hammers and sickles, depend in shape and size and weight on the characteristics and dimensions of their users.

*Industrial Physiology.*—There are many examples already of contacts between our two sciences. In this country the Industrial Health Research Board and the Institute of Industrial Psychology, in many of their activities, represent an application of physiological (or psychological) methods to the case of man in industrial processes or operations. The problems investigated are usually not medical ones, but are concerned with the behaviour of normal healthy bodies in relation to the processes of work, or in an industrial environment. The expenditure of energy in labour of various types; the conditions affecting fatigue in men and women; the nutrition of workers; heating and cooling; noise, rest pauses, skill, vision, illumination; these are examples of the kind of problems in which physiological advice is required in practical industry.

*Diving.*—Diving and the construction of underwater tunnels provide a classical case. These require that men should work at pressures considerably greater than atmospheric. This leads to the solution of a proportionally greater quantity of gas in the water of the body, with the danger that this may bubble off when the pressure is released, and mechanical damage be caused in delicate organs. The successful avoidance of "caisson disease," as it is called, in the workers, is an important practical matter, and has depended on the co-operation of physiologists and engineers.

*Work at High Temperatures.*—The construction of great engineering works in certain parts of the world, *e.g.*, of the dam at Boulder City, Nevada, deep mining, working in the engine-rooms of ships in the Tropics, and many other such processes, involve a considerable strain on the capacity of the body to keep cool. An understanding of the factors involved in cooling the body by evaporation of sweat, *e.g.*, of the need of water and a certain amount of salt, together with a reasonable margin of dryness in the air, and an appreciation of the fact that adaptation is gradual and that some persons can adapt far better than others to high temperatures, may be important to success in such undertakings. Usually, advice on these matters is left to the doctors on the spot; but many doctors are singularly innocent of physiology, and it might be best if some engineers themselves learnt at least the elements of the subject.

*Food Preservation.*—The health of a nation depends upon its food supply—probably more at present than upon any other factor. The adequacy, in quantity and quality, of the food, is partly a matter of biochemistry, physiology, botany, and zoology, partly a matter of economics and finance, but largely one of engineering. A determined application of the principles of engineering and biology, in conjunction, to the preservation, transport, and storage of foods, can probably make a greater contribution to human health, efficiency, and welfare than any single branch of medicine.

*Methods of Physiological Research.*—This lecture, however, was intended to describe, not industrial or applied physiology, but some more or less entertaining manifestations of engineering principles in the working of the body. It is not easy to study directly the more intimate mechanism of the human organism, for we cannot, legally or morally, take the machinery to pieces to examine it in detail; and even if our political and ethical systems allowed us—and anti-vivisectionists often urge that criminals should be used for experiments!—there would be many disadvantages in so doing. The behaviour, for example, of muscle and nerve is best studied in a variety of much smaller animals, particularly in cold-blooded animals, from which these organs can be removed (after killing the animal), when they will go on working well for comparatively long periods.

*Muscle.*—A large part of the body consists of voluntary muscle: called voluntary because it is directly under the control of the will, though many of its functions are carried out unconsciously and automatically. The physiological unit is the muscle fibre, a long contractile jelly-like structure, about $^1/_{30}$ mm. in diameter, about 47 I.W.G. The muscles are made up of large numbers of these units. At their ends the fibres merge into tendons, by which they are attached to bones. A fibre at rest, under a given tension, has a certain length. When excited, either artificially by an electric shock, or naturally by the so-called "impulse" coming to it from its nerve fibre, it "contracts," its length diminishing if the tension remains constant, its tension increasing if its length is kept constant. The unit of muscular response is a single twitch so-called; the mechanical change (tension or shortening) rises rapidly to a maximum and then rather less rapidly disappears, the whole cycle lasting for a time depending on the nature, the temperature, and the condition of the muscle. All muscular movements, or forces, are built up by the statistical fusion of these elementary units of muscular response, just as the pressure of a gas is the statistical result of the individual impulses of its component molecules.

*Static and Dynamic Functions.*—The functions of muscles are twofold: (1) static, to maintain the appropriate system of forces by which each posture of the body and of its component parts is preserved against gravity, or elasticity, or external load; (2) dynamic, to develop the extra forces by which movement is produced, kinetic energy developed, or work done. The same muscles have to perform both functions, and their properties represent a compromise. If a muscle is slow, *i.e.*, if the time occupied by its natural cycle of contraction and relaxation is long, the fusion of the individual elements of its activity to form a maintained contraction can occur with a slower rhythm of excitation, and the first, the static, function is performed more economically. If, however, movement is to be sufficiently quick, and particularly if kinetic energy—as in jumping or throwing—is to be developed in comparatively small masses, the muscle must be capable of shortening rapidly, and the maintenance of contraction will be expensive.

*Heat Production of Muscle.*—In the muscle twitch at constant length there is a rapid development of force, and an equally rapid production of heat. The force T multiplied by the length $l$ in which it is developed bears a constant ratio to the heat H: expressing T in dynes, $l$ in centimetres, and H in ergs, $T\,l/H$ is about 8. In this ratio we have a property of muscle which is approximately the same in different muscles, in the same or in different animals, at different temperatures and under a wide variety of conditions. In a maintained contraction, due to the fusion of a series of muscle twitches, in a given muscle under given conditions, the heat per second bears a nearly constant ratio to the product $T\,l$; but $(d\,H/d\,t)/T\,l$ varies widely from muscle to muscle, being less the slower the muscle. Expressing $t$, not in seconds, but in the local time $\theta$ of the muscle itself, *i.e.*, in units proportional to the duration of the elementary twitch, $(d\,H/d\,\theta)/T\,l$ is again approximately constant for all muscles and under all conditions.

These results apply to a muscle contracting isometrically, *i.e.*, at constant length. If work is done the results are not so simple, but in general there is found to be an extra liberation of heat more or less in proportion to the work. There are many signs of a precise thermodynamic mechanism in these relations between work and heat, but it is difficult to make any consistent model of all the facts. The most primitive and one of the most efficient engines in the world does not easily yield its secrets.

*The Recovery Process.*—The heat of which I have spoken is the "initial heat," that liberated during the contraction; but there is another quota of heat, of about the same magnitude, liberated *after* the contraction in the following five to thirty minutes. This is the "recovery heat," which is a sign of chemical processes in which the initial state of the muscle is restored. We must think of the muscle as working like an electric motor driven by current from an accumulator; as soon as charge is taken from the accumulator a recharging mechanism is started up, oxygen is consumed, and the state of the accumulator is restored. This arrangement allows the muscle to discharge itself at a very high rate (a runner can exhaust himself almost completely in forty seconds), at a rate very much higher than the supply of energy through contemporary oxidation would allow, and then to recharge himself comparatively slowly in the following recovery process, with the liberation of heat and $CO_2$ and the consumption of oxygen. Our muscular activity depends entirely, for its energy, on the ultimate oxidation of foodstuffs. If, however, that oxidation had been required to accompany, instead of to follow, the muscular activity, we should have been very poor creatures, never able to take any form of exercise more strenuous than that which, as things are, we can maintain for long periods. All types of violent effort involve a considerable discharge of our "accumulator" system, followed by a subsequent and much slower recharge. In this way we can exert ourselves, for a very short time, some five to ten times as strenuously as we otherwise could.

*The Chemical Accumulator System of Muscle.*—It

* The Institution of Mechanical Engineers, November 29th. Abstract of the twenty-second Thomas Hawksley Lecture, entitled, "Muscles and Nerves: The Maintenance of Posture, the Development of Power and the Transmission of Messages in the Body."

is easy to think of analogies to this general property of muscle, in any system in which potential energy is slowly stored, to be released more rapidly as needed—steam pressure, a head of water, the compression of a spring. The electrical accumulator, however, is a much better model, for in it the potential energy is stored in chemical form—as it is in muscle. In muscular activity certain chemical reactions, of a non-oxidative character, occur; in recovery these chemical processes are reversed, at the expense of energy liberated in oxidation. Some, at least, of these chemical reactions are known. Changes occur in various phosphate compounds, lactic acid is produced, and in recovery these chemical changes are reversed, and oxidation occurs to provide energy for the reversal. The relation between the heat and the chemical changes is fairly clear. That, however, between the chemical and the mechanical changes is still a mystery. We need to know much more about the physical chemistry and the molecular structure of muscle before we can even begin to guess—or to guess with any likelihood of being right—at the mechanism by which chemical energy is transformed directly into tension energy and mechanical work.

*Muscular Movement in Man.*—After this outline of the fundamental processes in muscle let us consider the case of man. In the limbs the muscles are geared up, usually in the ratio of about 8 to 1. Strength is sacrificed to speed. The muscles are, in fact, rather strong; the flexors of the human arm can exert an absolute maximum force of about 128 lb. per square inch. Single twitches occur very rarely in the body—only, in fact, in a few reflexes such as the knee jerk. All our voluntary movements are due to a succession of responses, fused together statistically. This is easily shown by sticking a fine needle electrode into the biceps and connecting it to an amplifier and loud speaker. Its point may readily be inserted into a single group of muscle fibres supplied by a single nerve fibre, and then the electrical accompaniments of the individual responses of that group of muscle fibres are heard as clicks. If the biceps is very gently contracted there is a slow regular series of clicks; as the contraction is strengthened the frequency of the series rises; first it sounds like a rattle, then it gives a low musical note, and finally a comparatively high one. The strength of the contraction is adjusted partly by the *number* of fibre groups which take part in it, and partly by the *frequency* with which these are stimulated.

*Oxygen Consumption as Measure of Energy.*—There is no reason to doubt that in human muscle the usual relations exist between mechanical effect and heat. The human skeletal muscle is a comparatively quick one, and correspondingly wasteful in maintaining a contraction, as anyone can test, if he does not already know, by holding out a heavy weight at arm's length. It is not practicable experimentally, particularly with the blood circulating, to measure the heat directly; but the oxygen consumption of a man can be measured rather exactly, and fortunately—whatever foodstuff is being oxidised—the energy liberated in the combustion of 1 litre of oxygen is about the same, namely, about 5·14 kilocalories or 15,860 foot-pounds. As expected, we find that the oxygen is used *after* and not during the exercise, though, of course, if the exercise is continued the oxygen consumption due to any one element of the exercise may occur during subsequent elements of it. After violent continued exercise, such as running a quarter-mile at top speed, there is a considerable "oxygen debt," as it is called. Some 15 litres of oxygen may be used in the subsequent 30 minutes, chiefly in the first 10 minutes, in effecting recovery. After 200 yards at top speed the oxygen debt may be as great as 10 litres. Energy, therefore, equivalent to 158,600 foot-pounds, or sufficient, if employed with 100 per cent. mechanical efficiency, to lift the subject about 1000ft. into the air, may be used in recovery from 20 to 25 seconds of exercise. This shows the significance and magnitude of the recovery process in man.

*Mechanical Efficiency.*—The mechanical efficiency, however, i.e., the ratio of work done to total energy expended in doing it, is not 100 per cent.; under optimum conditions it may be as great as 25 per cent.; usually it is less. Its value depends on the nature of the effort made and on the speed at which the work is done. If the speed is very high or very low the efficiency is less, as it is in other engines; there is an optimum intermediate speed. If muscles are used in so-called "static effort" during work, *e.g.*, in maintaining the limbs or body in some position necessary to the effort, energy is wasted without any corresponding quota of work. If negative work is done, as in lowering a weight or in walking downstairs, the "efficiency" strictly speaking, is negative, for the total energy expended remains positive, even though the work is opposite in sign. It is not, indeed, so expensive in energy to descend as to ascend, to lower as to raise, but still it is expensive. No energy (except heat or kinetic energy) is acquired by, or stored in, the body in descent, as it might be in an electric tram by running the motor as a dynamo. The muscles have to pass through a sequence of tension changes in letting the weight down, which means a positive expenditure of energy, even though the work is negative. The mechanical efficiency in pedalling a bicycle or in rowing a boat with sliding seat, under good conditions and not too fast, is about 20 per cent.—perhaps 25 per cent. as a maximum. Under most conditions it is less.

*Horse-power Developed by Man.*—What horse-power can a man exert, either (*a*) momentarily or (*b*) continuously for a longer period? The maximum rate of oxygen consumption of a vigorous man is of the order of 4 litres per minute. In a steady condition of exercise, therefore, he can liberate total energy at the rate of about 63,000 foot-pounds per minute. Of this, however, not more than about one-fifth can appear as mechanical work, which corresponds to about 0·38 h.p. For a short interval, however, a man can expend energy at a much higher rate by running his accumulator down, so to speak. The mechanical power, however, is not correspondingly greater, for a high speed is inefficient. For a very short time a runner of 160 lb. weight could probably run up a hill of 1 in 5 at a horizontal speed of 8 yards per second. This represents about 1·4, or counting the air resistance, 1·5 to 1·6 h.p. Even at 5 yards per second it is about 0·9 h.p. Such efforts, however, are very exhausting, and lead rapidly to a large oxygen debt. Rowing and running involve a greater part of the body's musculature than other forms of exercise. With more limited efforts, *e.g.*, by the arms and shoulders alone, the power output is far less. It is sad to reflect that *homo sapiens* at his best cannot develop more than about a kilowatt of mechanical power, and that only for a few seconds at a time.*

*Conclusion.*—This is but an interim report. We are only at the beginning of knowledge of the actual mechanism of living processes. In a few years it will almost certainly be found that some of the facts and relations have had too much, others too little emphasis laid upon them. That is inevitable. I believe, however, that the facts, as stated, are really facts, and that they at least will stand the stress of time. Had I been speaking to philosophers or mathematicians, or even to physicists or astronomers, I might have been tempted to lay more emphasis on theories; but, as I said at the beginning of this lecture, physiologists are more at home with engineers, and to them I have tried to describe facts, the relations between facts, and the deductions from facts, observed as accurately as possible, without venturing too far away from a safe anchorage. Perhaps it may be said that I have ventured into metaphysics by insisting that these things are ultimately explicable in reasonable terms, that there is no magic standing to bar our way in exploring even that most sacred fastness, the human nervous system, the seat, or at least the accompaniment, of consciousness itself. That much faith, based as it must be for a long time yet on very imperfect evidence, one must be permitted, if one is to go on. Engineers will sympathise with it, for without considerable faith your greatest achievements also would never have been made, and mankind would be much the poorer. That there is no magic to stop us on the road I feel sure, and that mankind would be poorer if we stopped for any other cause is a reasonable conclusion from other branches of research. But whether we shall ever reach the end of our scientific journey I will not guess; for what evidence is there, after all, that there is an end?

* In the second half of his lecture Professor Hill discussed the mechanism by which the muscles are controlled through the instrumentality of nerve fibres and cells.—ED., THE E.

## Problems of River Pollution.†

THE quantity of waste water from a beet sugar factory of average size is approximately 3 or 4 million gallons per day. These wastes, if discharged untreated into a stream have about the same polluting effect as the domestic sewage from a population of several hundred thousand people. In the case of effluents from dairies and milk products factories, the polluting effect of the washing waters from a milk-collecting and distributing depôt handling 10,000 gallons of milk per day is about the same as that of the domestic sewage from a population of 1000 people. If whey is discharged to a stream instead of being utilised, its effects may be disastrous, as whey is at least 100 times as polluting in character as an equal volume of domestic sewage. With regard to the problem of disposal of effluents from dairies and milk products factories also, the work of the Board has already indicated that the washings from churns, other equipment, and factory premises can be satisfactorily purified by oxidation by processes similar to those in operation at many sewage disposal works. In the case of beet sugar factories investigations completed by the Water Pollution Research Board have shown that after simple preliminary treatment the waste waters can be re-used in the factory processes and there need be little or no effluent for disposal.

In the last few decades new industries have been developed, factories have been set up in areas not previously industrialised, and there have been consequent movements in the population. These changes have led to the pollution of many rivers and streams which were comparatively pure until a few years ago. Fortunately it is becoming realised that uncontrolled discharge of polluting wastes adversely affects not only the health and recreations of the population, but also the interests of industry, agriculture and fisheries. There are, for example, many instances in which unrestricted discharges of waste liquids from factories have rendered water supplies most easily accessible to adjacent factories quite unfit, except after costly treatment, for the purposes for which they are required. With regard to the disposal of domestic sewage, there are methods of treatment in use in many districts, particularly in the larger inland towns, whereby the sewage liquid can be purified sufficiently to allow of its discharge into most rivers and streams without causing serious pollution. These methods, however, are an expense to the community and the total costs, including sewerage, amount to several shillings per year per head of the population. The expense is undoubtedly justified, but it is highly probable that by systematic scientific investigation the methods can be improved or rendered less costly. One problem which has not yet been satisfactorily solved is that of the disposal of sewage sludge. Some of the sludge, after a certain amount of drying, is sold as a fertiliser, but it does not always find a ready market. So far as trade effluents are concerned, there is an enormous amount of work ahead before practicable methods of dealing in an entirely satisfactory manner with the waste waters from all the various trade and manufacturing processes in operation to-day will be discovered. In addition, new processes and industries are certain to be developed from time to time, and these will bring with them new problems of disposal of wastes. In attempting to solve any problem of treatment and disposal of trade wastes, the first step should always be to consider the practicability, taking costs into account, of so modifying the manufacturing processes that the wastes need not be produced or their quantity and polluting character can be reduced. There is frequently the possibility of recovering products of value from the wastes and at the same time improving their quality. The next step is to find satisfactory methods of treatment and disposal of the remaining effluents.

† Abstracts from a lecture by Dr. Parker, Assistant Director of Water Pollution Research, D.S.I.R., before the Society of Chemical Industry, Bristol, December 2nd.

## Literature.

### SHORT NOTICES.

*Power Operator's Guide.* Edited and compiled by E. J. Tangerman. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 24s. net.—This book is a collection of one thousand and one of the practical notes which have been published in issues of the American journal *Power* for many years. These notes, sent in by plant operators, mechanics, and engineers, describe ideas which they have evolved in their work and adapted to their respective plants to save time, labour, and money. They cover all branches of power engineering, including fuels, oil, gas and steam engines; turbines; boilers; pumps; compressors; transmission; bearings; building services, &c. There is no doubt that the volume will give useful information to all connected with plant operation and maintenance, and it is, moreover, one of the class of books which can be taken up at any time and read with interest.

*Elements of Electrical Engineering.* By Arthur L. Cook. London: Chapman and Hall, Ltd. Price 20s.—Since the first appearance of this book in 1924, changes in electrical practice have been made, and this third edition brings the subject matter up to date. The author's original object, however, namely, to provide an introductory course for students of electrical engineering or a text-book for students not specialising in this branch of engineering, has not been altered. Numerous changes have been made in the text, and new material has been added to many of the chapters. Progress in the development of thermionic tubes of various kinds has necessitated drastic revision of the chapters relating to them. Similarly, the chapters on A.C. circuits and machinery have been largely rewritten and considerably extended, particularly those on the A.C. motor and transformer.

*How Wireless Came.* By John Langdon-Davies. London: George Routledge and Sons, Ltd. 1935. Price 6s.—This book describes the scientific history of wireless in a simple way, and although it is apparently mainly intended for young people, it may appeal to others in need of elementary wireless instruction. It represents one of the many attempts made to deal with a technical subject on popular lines, and although it is naturally not to be recommended to serious students of the subject, it may easily serve to stimulate a desire for further knowledge on the part of scientifically inclined people.

### BOOKS RECEIVED.

*Highway and Road-Traffic Law.* By R. P. Mahaffy. London: Ed. Arnold and Co., 41, Maddox-street, W.1. Price 15s. net.

*Timber Seasoning.* By R. G. Bateson, B.A. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 6d. net.

*The Resistance of Piles to Penetration.* By R. V. Allin, M. Inst. C.E. London: E. and F. N. Spon, Ltd., 57, Haymarket, S.W.1. Price 10s. 6d. net.

*Nel Cinquantenario della Società Edison*, 1884–1934 (*On the Fiftieth Anniversary of the Società Edison*). Four volumes. Mijan: Società Edison, 31 Foro Bonaparte, Italy. No price stated.

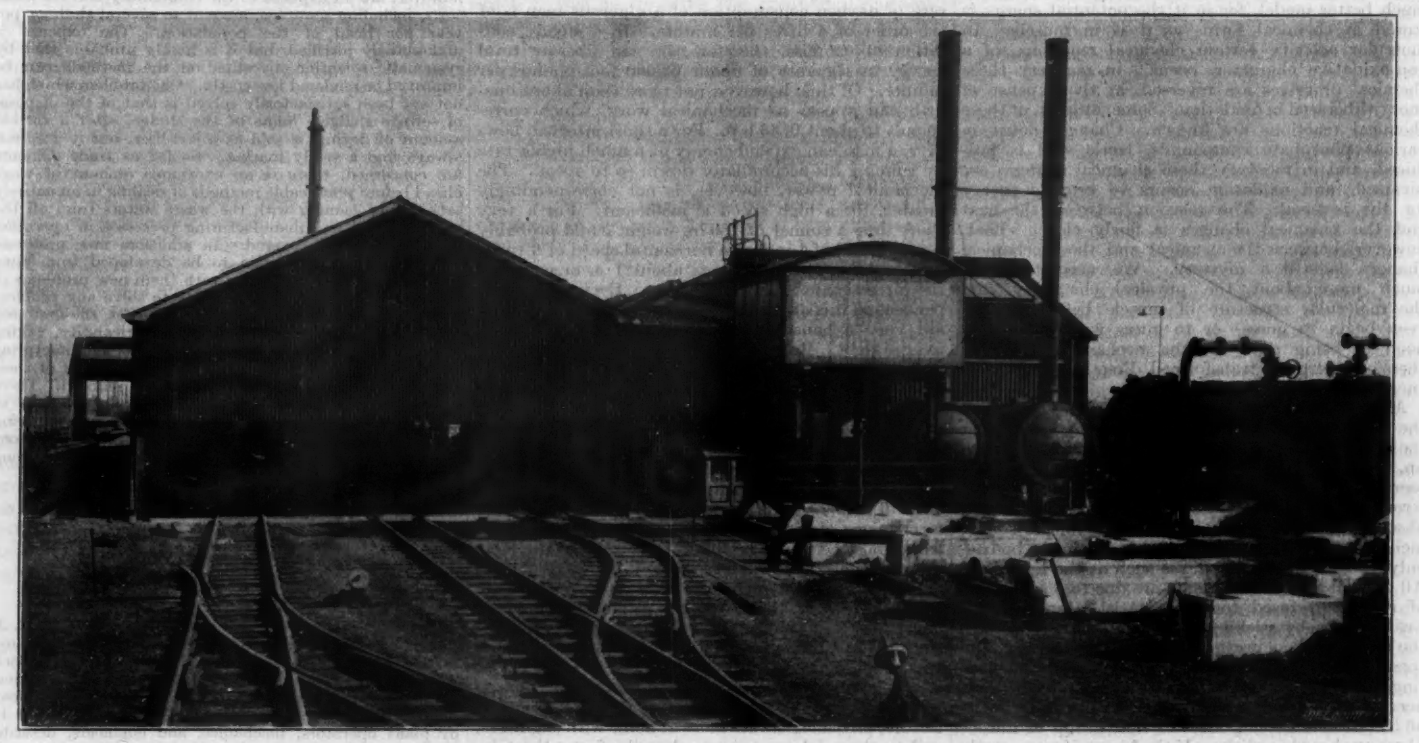
*Steel of Empire: The Romantic History of the Canadian Pacific, the North-West Passage of To-day.* By J. M. Gibbon. London: Rich and Cowan, Ltd., 25, Soho-square, W.1. Price 21s. net.

*Engineering Economics.* Book 2. *Works Organisation and Management.* Third edition. By T. H. Burnham, B.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 8s. 6d. net.

*Further Experiments Upon the Water Gas Process.* By J. G. King, Ph.D., B. H. Williams, Ph.D., and R. V. Thomas, B.A. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 1s. net.

*Globe Commercial Correspondence: Combined with the Globe Code System.* Three volumes, English, Deutsch, Français. By Harald Gyllstoff. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, Kingsway, W.C.2. Price 6s. each volume.

NEW G.W.R. SLEEPER CREOSOTING DEPOT AT HAYES, MIDDLESEX



# New G.W.R. Sleeper Creosoting Depot.

THERE has recently been put into operation by the Great Western Railway a new sleeper-creosoting plant estimated to have an annual capacity of nearly half a million sleepers. The creosoting depôt is at Hayes, Middlesex, on the main line, where the proximity of the Grand Junction Canal produces an advantageous site at which timber can arrive from the London docks or elsewhere by barge, and the completed sleepers be despatched to their destinations by rail. The new plant replaces that which has existed for some years on ground near by. The original plant—see the sketch map, Fig. 1—was erected on the ground between the Paddington canal and the Yeading Brook. This space it is now planned to use in its entirety as a stacking yard. For the erection of the new plant in the position shown on the plan it was necessary to build up the ground level at the site to make a suitable gradient between the main lines and the canal. Consequently, a large amount of work had to be carried out before the erection of the new depôt could be commenced. In fact, much work still remains to be done, while the dismantling of the old depôt and its conversion into a stacking yard is not yet finished. The work included the erection of a bridge over the Yeading Brook.

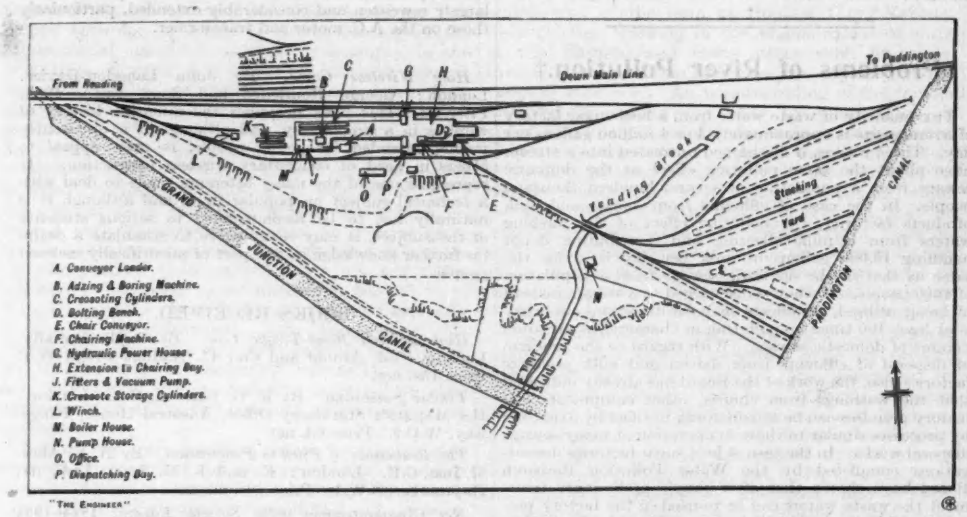



FIG. 1—PLAN SHOWING SITUATIONS OF CREOSOTING DEPOT AND STACKING YARD

### ARRANGEMENT OF PLANT.

The general arrangement of the plant will be understood by the examination of the plan—Fig. 1—and of the engraving at the head of this page, which is a view of the western end of the depôt. Creosote is delivered in 3000-gallon travelling tanks and discharged by the use of vacuum into storage tanks K, one of which is seen on the right of the engraving. Eventually, there are to be three storage tanks, each 6ft. in diameter, with a total capacity of about 39,000 gallons. Two tanks will be 72ft. long and the other 66ft. 6in. Water is obtained from the canal and gravitates to a pump-house N on low ground by the Yeading Brook, from which it is pumped to the storage tank seen in the engraving. The pumps are switched in and out automatically. Steam for pressure pumps and heating the creosote, &c., is raised in two locomotive-type boilers, the fire-box doors and chimneys of which are visible in the engraving. To the left there are also to be seen the ends of the two creosoting cylinders C. Chairs and bolts for fitting to the sleepers are delivered to the eastern end of the building, and the finished product is loaded into crocodile wagons at the despatching bay P. Most of the plant at the creosoting works is electrically driven, and the main switchgear is erected in a room in the office building O.

### ADZING AND BORING.

The timber, Baltic Redwood Pine for sleepers, and Douglas Fir for crossing timbers, arrives by barge on the Paddington canal cut approximately to the correct length and thickness. It is lifted from the barges and stacked by steam travelling cranes made by Thomas Smith and Sons (Rodley), Ltd., and illustrated in Fig. 2. These cranes can lift 5 tons at 18ft. radius or 30 cwt. at 40ft. radius, and, as will be seen, are adapted for loading the timber into stacks up to about 40ft. high. Timber remains in the stacking yard for about six months (according to condition of the timber) to season before it is drawn upon for use. At the expiration of this period the crane loads it into trucks on which it is hauled to the creosoting depôt and discharged by the same crane on to the conveyor loader A. At this point a workman hauls the sleepers one at a time down a slope on to a roller conveyor which carries them into the western end of the building and delivers them to the feeding end of the Robinson adzing and boring machine. Just before its discharge off this conveyor each sleeper is caused to pass beneath a swinging flap so adjusted for height that it will be swung back by any sleeper which is too thick to be fed into the machine. By this action the electrical circuit to the conveyor motor is broken and the motion of the conveyor consequently stopped. The attendant responsible for transferring the sleepers on to the feed chain of the adzing and boring machine must then operate a master control button to keep the conveyor in motion, and, on the arrival of the offend-

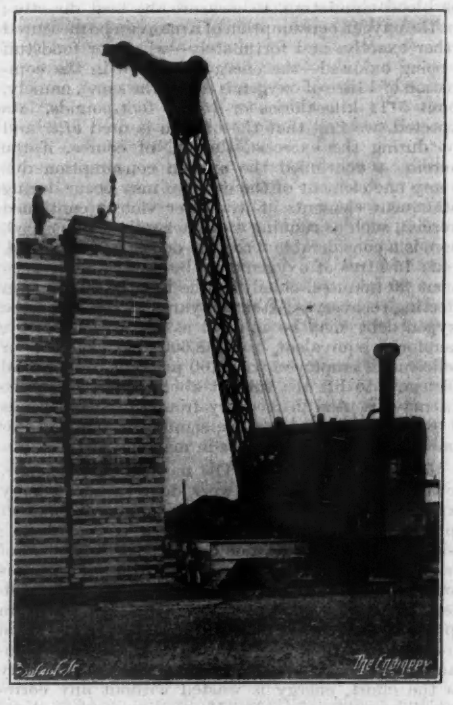


FIG. 2—STEAM TRAVELLING CRANE

ing timber, pushes it into the reject pile. Sleepers that pass the flap successfully are pushed in the other direction on to the chain feeder of the machine. As this tool was very fully described and illustrated in our issue of August 25th, 1933, it is unnecessary to make further detailed reference to it here. The first operation performed on it is that of sawing the sleeper to the desired 8ft. 6in. length by means of a circular saw, and the sleeper then passes under the adzes and comes to a halt for the boring of the chair holding-down bolt holes. Thence, as shown on page 596, it is fed up a delivery ramp for loading on to a trolley. The adzing and boring machine is capable of dealing with six sleepers per minute, and is fitted with a dust extractor which is to be seen partly erected in the engraving. On the feed side two arms are fitted one on each side and act as a safety device should a sleeper for whatever reason be fed in out of square. Should one arm be struck before the other, a bell is caused to ring warning the operator to trip the electric switch, and also informing any workman in the neighbourhood whom it may concern that the feed has stopped.

### THE CREOSOTING CYLINDERS.

Each of the trollies on to which the sleepers are loaded takes sixty sleepers. When a train of ten trollies has been loaded it is hauled out into the yard by the use of the winch L—Fig. 1—and allowed to run back by gravity into one of the creosoting cylinders—Fig. 4. These cylinders, of which there are two, are each 90ft. long by 6ft. 9in. internal diameter, and they were made at the Swindon locomotive works. Rails to carry the trollies are laid along each cylinder and a perforated plate between the rails hides the steam heating pipes, and the entry and exit ports for the creosote. Naturally, when the cylinders are filled with creosote there is a considerable uplift exerted on the trolley loads of timber, and to prevent them leaving the rails projections on the trollies pass under angle irons running longitudinally along the cylinders, as can be seen in the engraving. Each cylinder will hold ten trollies of sixty sleepers each, or 600 sleepers altogether. As soon as the "train" is in place, the drawbridge is lifted and the hinged door at each end closed. Engineers will at once recognise from the engraving the type of mechanism adopted for locking the doors. After closing and by the use of a sector rack and pinion mechanism lugs on the periphery of the door are caused to pass behind corresponding lugs on the end of the cylinder. The automatic dropping into place of a "key" at the base of the door when the lugs are "home" prevents unpremeditated opening of the doors, for the lugs cannot be disengaged until the "key" is lifted by hand. Pressures up to 200 lb. per square inch can be exerted within the cylinder, and special means had therefore to be taken to ensure a tight joint. Around the jointing face of the door there is inserted a pear-shaped lead pipe ring into the interior of which, when the door is closed, high-pressure water is admitted. The whole operation of closing and sealing a door can be carried out in less than a minute.

As soon as the doors are sealed the Worthington-Simpson motor-driven vacuum pump illustrated in Fig. 6 is started up and creates in less than eight minutes a vacuum of 25in. of mercury within the cylinder. Creosote is then admitted from steam-heated "working" or feed tanks beneath the cylinders, and a period of another eight minutes or so allowed for filling. In order that the vacuum pump shall be protected from the admission to its cylinders of creosote, there is a safety valve in the suction pipe which opens at 25in. vacuum, and the legs of the inverted "U" suction pipe are made of suitable length. Steam meanwhile has been admitted to the heating pipes within the cylinder in order to maintain the temperature of 150 deg.–160 deg. Fah., at which the creosote was admitted and as soon as the cylinder is full all valves are closed and the steam-driven creosote pressure pumps are started up. The pressure adopted depends upon the kind of timber undergoing creosoting. For Baltic Redwood Pine, of which sleepers are made, a pressure of 60 lb. per square inch maintained for thirty minutes has been found sufficient. But for crossing timber of Douglas Fir a pressure of as much as 200 lb. per square inch must be maintained for 3½ to 4 hours. The penetration for Baltic sleepers is from ¼in. to 1in., and 600 sleepers absorb about 1690 gallons of creosote, and crossing timbers about 24 gallons per 50 cubic feet. At the conclusion of the creosoting period the oil is drained from the cylinder and vacuum applied for fifteen minutes or so to get rid of surplus oil. The doors are then opened and the train of trucks is run on to drainage pits and then down to the eastern end of the building, where the sleepers are unloaded on to the "bolting" bench, seen on page 596. Here the bolts are driven in to the previously bored holes, and each sleeper is turned over and allowed to slip down a ramp on to a roller conveyor, which carries it to the chairing machine F—Fig. 1. The motion of this conveyor is controlled according to his requirements by the operator of the chairing machine.

### THE CHAIRING MACHINE.

Chairs are delivered by rail to the depôt at the point E—Fig. 1. Here they are unloaded on to a belt conveyor 200ft. long—Fig. 5—which discharges on to a gravity roller conveyor, 35ft. long. This latter conveyor, as can be seen on p. 596, runs practically parallel to that carrying the sleepers, and the chairs are transferred from it and dropped over the bolts in the sleepers. Nuts are screwed on lightly and each sleeper passes into the chairing machine which is capable of dealing on the average with 120 sleepers per hour. As soon as a sleeper comes into position an hydraulic ram is forced down on to each chair with a pressure of 10 tons, holding it firmly in position. Friction-driven spindles are next lowered to engage the nuts and screw them home. The friction devices, consisting of groups of discs peripherally in contact, can be seen in the engraving at the top of each headstock.

### DESPATCH.

From this machine the sleepers travel on a roller conveyor to the elevator illustrated on page 596. As soon as a sleeper comes into line with the latter its end pushes back a lever which causes the mechanism seen in the foreground of the illustration to operate and to push the sleeper on to the elevator. From the top it is loaded directly into a "crocodile" truck for delivery to whatever part of the railway it is wanted. A device has been fitted to the elevator since the photograph was taken, which ensures that each sleeper is properly "caught" by the "claws" of the device. The elevator can travel at any speed between 6ft. and 30ft. per minute. This chairing plant is to be duplicated on the northern side of the depôt in the space marked H on the plan—Fig. 1.

In conclusion, we should like to acknowledge the

FIG. 3—ADZING AND BORING MACHINE

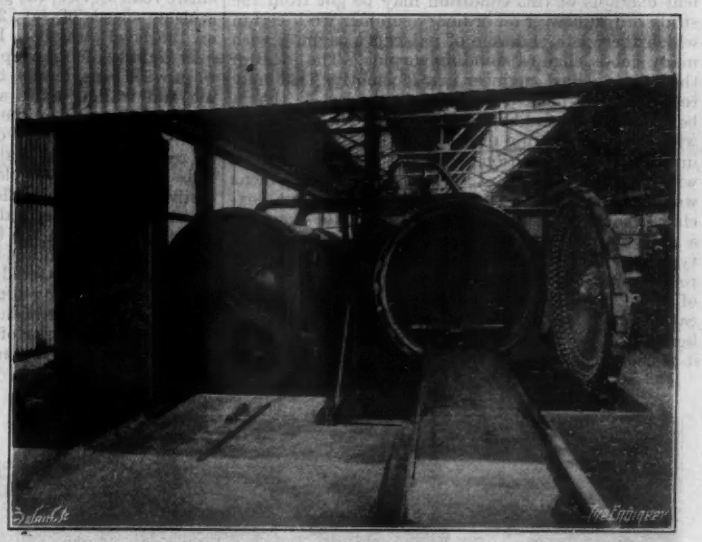


FIG. 4—CREOSOTING CYLINDERS

FIG. 5—CHAIR CONVEYOR

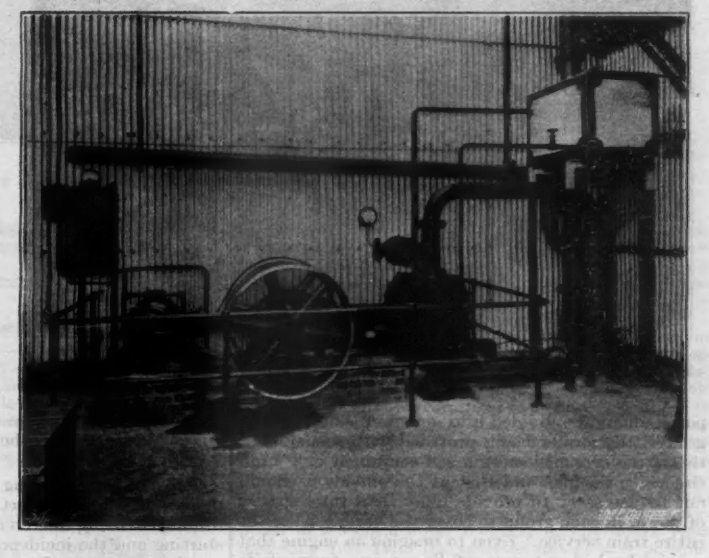


FIG. 6—VACUUM PUMP

courtesy with which the representatives of the railway company showed us the plant, and made available to us the technical particulars on which this article has been based, and the photographs by which it is illustrated.

## The Geared Locomotive.

*(By a Correspondent.)*

ONE of the most unsatisfactory features in the operation of large running sheds under existing conditions is the specialisation of locomotive power into sections, passenger, goods, mineral, &c., as it involves considerable waste on account of the necessity of retaining a sufficient stud of each class of power to cover the maximum demand of each section. There is in consequence bound to be a proportion idle during sectional slack periods which are not suitable for other and temporarily busier sections. An excellent example of this condition may be got from the study of traffic over an ordinary summer week-end in which there is a shortage of passenger engines, with many goods engines standing surplus. The ideal of the running shed engineer is a locomotive that may reasonably be booked out on any service, so that a better balance may be struck and the shed operated with a smaller margin of power. This is not possible under present conditions, but it is submitted that with altered conditions very great improvement would be possible. The principle of universal exchange cannot be carried to its limit, as, for example, a good road engine makes a poor yard engine, special types are needed for short services with quick turnround, &c., but it should be possible to build classes of locomotive power having much wider service applications than at present. Omitting such details as light units for small branch passenger services, &c., it is thought that with this ideal in view locomotive power should be divided into long and short haulage groups, the former being provided with tenders and the latter arranged on the self-contained or "tank engine" principle, and that at the outside it should not be necessary to provide more than three grades of power in each group to cover the variations of the entire train service. Even to imagine an engine that can be booked out successfully on any train of its group is admittedly revolutionary, but it is by no means an impossibility, as will be shown. The main departure from orthodox practice being nothing more serious than a three-speed gear-box following the lines of the internal combustion chassis assembly, but without reverse. The relevant question is the ability of the gearing to stand up to the duty demanded from it and the answer must surely be in the affirmative, bearing in mind the accuracy of present-day gear-cutting, added to the scientific suitability of the metals employed. Geared driving is by no means a new idea, and on present experience, especially in connection with steamships and electrically driven trains, there should be no doubt about its ultimate satisfactory service.

The deciding factor in the design of power suited to high speeds is the piston velocity on account of the loss through inertia at each end of the stroke, which is increasingly serious with advance in speed. It is impossible to reduce this velocity by increasing the diameter of the driving wheels, and, in fact, it has been found necessary for some years past to reduce diameter to allow for the necessary enlargement of the girth of the boiler and the coupling together of groups of wheels for the sake of increased adhesion. With the freight engine the limiting factors are the length of train, together with the strength of the standard wagon coupling; the extension of a freight train into a second section would raise awkward signalling problems, and judging from the returns of broken couplings the present standard is already stressed up to the working limit. It therefore appears that the requirements of a good locomotive for the long-haulage group are the usual ample boiler capacity convertible at will through a change-speed gear-box into various economic speeds, and if the broad classification of passenger, goods, and mineral be agreed upon the case for a three-speed gear-box will be established. The next consideration is the diameter and number of the coupled wheels. As already suggested, the day has passed in which high diameters were considered necessary to high speeds. As regards the freight services, there is a distinct tendency to augment the former small diameters on account of the increasing speeds. A compromise diameter of 5ft. 6in. to 6ft. would seem to be most suitable, and the wheel arrangement should be divided into eight-coupled arrangements for the two heavier and six-coupled for the lighter classes, it being thought that a range of three sizes should be sufficient to cover the entire road service, the gearing being arranged to give cruising speeds of, say, 25, 45, and 65 miles per hour on the level straight. In case of doubts about the over-rigidity of four coupled axles, it is always possible to provide considerable flexibility by giving the leading and trailing axles side play within limits, and allowing for this in the coupling-rods by means of two vertical pin joints or their equivalent. It may be recalled that the trailing length of the coupling-rods of the "1500" class of the ex-Great Eastern Railway was rendered flexible by a vertical pin joint just behind the intermediate crank pin, together with a radiused brass in the trailing rod-end free to move in the rod at the radius from the pin of the joint. A warning may be uttered here against the principle of inducing re-centring after curving by varying the weight on either or both of the axle-boxes concerned. This is the forerunner of many a heated box, and a better scheme is re-centring by means of an horizontal spring, after the manner of the radial axle-boxes designed by the late Messrs. Webb and Worsdell.

Many of the foregoing remarks apply to the locomotive destined for short haulage work, the principal differences being that on account of the need for quick starting and the incidence of lower average speeds a smaller diameter of coupled wheel, say, about 4ft., is indicated, together with an increase of coupled wheels to ten and eight respectively, it being probable that only two sizes of power would be needed for this group. Such engines should be serviceable for suburban passenger, local freight, and shunting work, and, in fact, for all services excluding the small branch passenger for which the compression ignition or the Sentinel type of self-contained coach and engine seems to be growing in favour. A further exception may be made in favour of light one-man engines for docks and small goods yards. In addition to the all-round availability in the running shed, there are many mechanical advantages inherent in gear-driven engines, the principal being the greater evenness of the turning moment on the driving axles and the absence of hammer blow, due to unbalanced rotating masses on the rails. An even turning moment reduces the tendency of the driving wheels to slip at starting, possibly to such an extent that sanding gear would be rendered unnecessary, and the effect of hammer blow on the rails is well known, though generally disregarded. A combination of mechanical and operating advantage is the total enclosure of the engine unit for the purpose of automatic lubrication with its attendant saving of lubricant and enginemen's preparation time, a daily, or sometimes twice-daily, period mostly occupied in pouring oil into the innumerable holes and receptacles of the orthodox type of engine. Automatic lubrication ensures circulation of the lubricant, instead of loss after first use. But the principal is the day-to-day advantage to the railway, as well as to the running shed, of an engine that can be booked out with certainty on some service or other on every working day in the year. Bearing this ideal in mind, the time is surely ripe for an advance along the lines suggested herein.

## British Oxygen Company's New Works.

FOLLOWING a luncheon held at Grosvenor House, Park-lane, on Monday last, December 2nd, a visit was made to the sales technical service department of the British Oxygen Company, Ltd., and the company's technical and research department at the new works, North Circular-road, Cricklewood, N.W.2. The premises comprise a welding and cutting instruction school, a lecture theatre, exhibition show-room, demonstration shops, and executive offices. In the main demonstration shop there is a complete range of the company's oxygen-cutting machines, welding equipment, hand cutters, and equipment for lead-burning, brazing, soldering, &c. In the smaller rooms adjoining are the metal-spraying and arc-welding demonstration shops. Here, prospective customers will see a complete range of the company's equipment under actual working conditions, and can more easily decide the type of apparatus most suitable for their requirements. A firm may wish to know if the oxy-acetylene process, metal spraying, &c., will be suitable for the particular class of work it has in hand. In the demonstration shop practical tests can be made on the actual job, to ascertain its suitability and to obtain a measure of the cost which would be involved. The welding and cutting instruction school provides tuition for customers or their operators who have purchased equipment. But subsequent instruction can be given at any time, and it may happen that a firm using one or other of the processes takes on a different class of work and requires special instruction, which can be given in the school. The provision of a separate instruction school enables students to work without the distraction which might be occasioned by the work always in progress in the main demonstration shops. The lecture theatre is equipped for the showing of cinema films or lantern slides. Monthly illustrated lectures will be given here, and be open to customers, members of the company's staff, or, in fact, to anyone interested in the industry. It may be mentioned that the company has its own cinematograph operator, and produces most of the technical films shown. These films are available for loan to welding schools, technical societies, and so on. Another use for the lecture theatre is to amplify instruction given in the welding and cutting school by showing slides or films relative to particular work. The exhibition show-room contains, as far as possible, a complete display of all the company's products. More particularly it is intended to show specimens of work carried out by means of the various processes, and to show what can be done by means of welding, cutting, &c., to improve the technique of those already using the processes, and to assist in the development of new equipment and applications.

INSTRUCTION SCHOOL

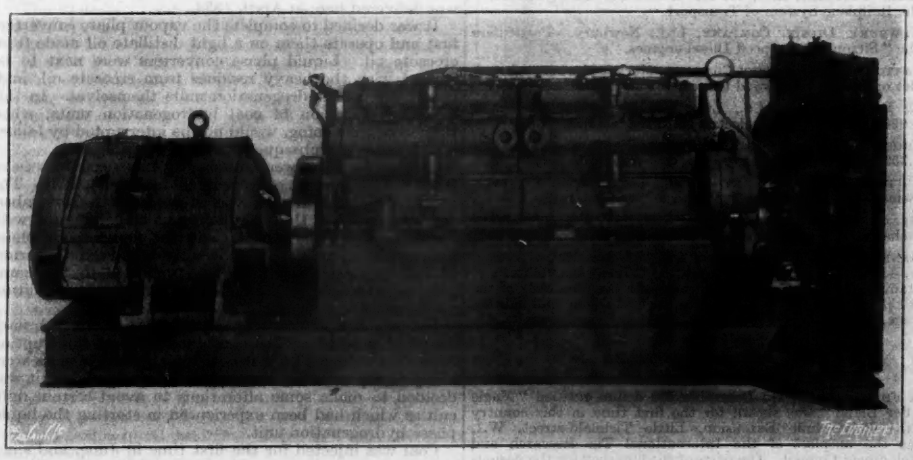
DEMONSTRATION SHOP

It is interesting to note that in the construction of these buildings all the heating radiators are of welded steel and all the pipes for the heating system have welded joints, connections, and branches. All sanitary and water service piping is either of welded copper or where lead is used, oxy-acetylene leadburning has been adopted as the means of jointing. Many of the ceilings are constructed of steel panels, and in the lecture theatre and show-room the steel ceiling has been metal-sprayed with aluminium, obtaining a permanent decorative effect not possible by other means. Incidentally, the furniture in the lecture room and in the offices is of welded steel construction. The work of the company's technical and research department, which has been situated at Cricklewood for many years, has an important bearing on the service available from the company. In these laboratories all the company's raw materials and products, such as welding rods, fluxes, purifying materials, carbide, &c., are regularly tested in order to maintain the high standard required. Analyses are made, on behalf of customers, of special

metals or other materials. The technical and research department is responsible for all forms of chemical or metallurgical control and research in connection with the industry. The most up-to-date apparatus has been installed. In the chemical laboratory there is the Sands apparatus for electro-chemical analysis, and the Hilger steeloscope for determination by spectrum methods of small proportions of rarer elements in certain steels and alloys, as well as other special apparatus suited to the nature of the work dealt with. In the metallurgical laboratories the equipment includes high and low-power photo-micrographic apparatus, binocular prism microscopes with photo attachment for macrographic work, and a Philips' X-ray apparatus for the radiographic inspection of welds. Here a number of interesting views of X-rayed welds may be seen. The mechanical testing department includes 100-ton Avery and 30-ton Buckton testing machines, a Hounsfield tensometer, &c. Special attention is being given to the provision of facilities for the non-destructive testing of welds. The laboratories include a section devoted to the designing of special apparatus and the manufacture of experimental equipment.

## A Ship's Emergency Generating Set.

IN the accompanying engraving we show an interesting example of a ship's emergency generating set, which was recently completed by the Parsons Oil Engine Company, Ltd, of Southampton, for Harland and Wolff, Ltd., of Belfast, and will be installed in the new McIlraith and McEarchern liner "Kanimbla" The engine is one of the firm's "M C S." series and is designed to run on vaporising kerosene fuel. Provision is made for hand starting by two men, although the unit can be easily started by one man. For starting, petrol is used when the engine is cold and kerosene fuel when it is warm, special spray injection to the inlet pipe being provided. The circulating water system includes a positive type pump with radiator cooling, and the fan is a self-contained unit, which is built into the radiator and is driven direct through a fabric coupling. The engine is equipped with a close-speed governor, which makes direct lighting supply possible under all conditions of load. The eight-cylinder arrangement is very smooth in running and even when developing the maximum power of 80 to 82 b.h.p. there is, we are informed, a remarkable absence of vibration. The individual components are comparatively light in weight to facilitate handling, and, as our illustration clearly indicates, very small headroom is occupied by the unit, which gives easy access for examination and dismantling. The set is designed for continuous harbour use, as well as for emergency services. The generator is of the Laurence Scott-Electromotors type, with a designed output of 50 kW at 220 volts. It is a compound-wound machine with a designed running speed of 1000 r.p.m. The whole of the plant described was built in accordance with Board of Trade and Lloyd's Register requirements.



50-KW EMERGENCY SET

## A Ropeway Extension Frame.

IN the issue of THE ENGINEER of May 8th, 1925, we described, among others, an aerial ropeway installed at the Wyndham Colliery, Ogmore Vale, of Cory Brothers and Co., Ltd., by R. White and Sons, of Widnes. It is used for the disposal of the dirt coming from the colliery, and was originally 3180ft. long, which provided about half a million tons tipping capacity. This space was all filled up, and in 1933 the colliery proprietors gave an order to White's to increase the tipping capacity by means of one of their patented dumping frames. These frames gradually crawl up the tip as it is made, the ropes being appropriately extended. The one at the Wyndham Colliery is illustrated by the accompanying engravings.

This frame was erected on the top of the existing heap, near the start of the original tip, the idea being to carry it forward in sections of about 21ft. to a total length of 870ft.

The principal feature of this system is that the return wheel and return rail of the terminal are mounted on a hinge, so that they can be turned back out of the way, as shown. The extension girder is then put in place, the wheel and rail are moved forward along slides provided for the purpose and lowered down into position again when tipping proceeds in a normal manner.

This extension frame has now been in use for about two years, and we understand it has given every satisfaction in working to the colliery company.

ROPEWAY EXTENSION FRAME AT WYNDHAM COLLIERY

## Street Surface Brightness Meter.

THE brightness of the street surface has been found to be one of the most important factors governing the visibility of objects, and a little experience with a brightness meter will enable the illuminating engineer to draw valuable conclusions. Although such a meter does not give a direct numerical measure of the excellence of every installation, its readings are more closely related to visibility than those of any other instrument. The G.E.C. meter shown in the accompanying illustration is a simple visual photometer, giving results of sufficient accuracy for the purposes for which it is used. It consists of a rectangular box with a long horizontal window through which the observer views the street and sees superimposed upon it a row of small spots of increasing brightness, which can be read in terms of effective foot-candles on scales in front of the spots. The ranges available for tungsten filament lamp lighting are 0·2 to 8·02 to 0·8 e.f.c., and 0·002 to 0·8 e.f.c., and are set by means of a rheostat and volt-meter. Having selected the point on the road surface at which a measure of the brightness is desired, the observer looks at the point with one eye and moves the instrument until he finds a spot having a brightness approximately equal to that of the point on the road surface. If the instrument is held about 18in. from the eye, the spots can be focussed sufficiently well, and with a little practice the instrument can be used with ease.

BRIGHTNESS METER

The spots in the instrument are formed by patches of silvering on a glass slide protected by another piece of glass cemented to it. The patches reflect a translucent window illuminated by a small lamp supplied by a small dry battery through a rheostat and arranged to give a brighter light at one end of the instrument than at the other. For use where mercury vapour electric discharge lamps form the lighting installation, a blue filter is inserted in a slot in the instrument to give a convenient colour match, and the readings are then taken on the lower of the two scales.

When the observer is standing in a position which the driver of a vehicle would normally occupy in the road (generally 10ft. from the nearside curve), it is possible to take readings of maximum and minimum brightness, but neither of these is necessarily very important, although the ratio of maximum to minimum brightness in the carriage-way ahead of a car may give an indication of the effective distribution of light over that important area. The intermediate values of brightness, particularly at the positions against which objects will be seen when they are 150ft. to 300ft. ahead of a car, have a large effect in determining visibility, and it is useful to measure under the conditions mentioned the general level of brightness on the road surface still further away.

A NEW type of electric gauge for measuring the thickness of porcelain enamel, paint, or other non-magnetic materials, such as celluloid, glass, mica, &c., which have been applied to or laid on flat sheets or plates of steel or iron, has been introduced by the General Electric Company of New York, and is described in a note in the *Electrical Review*. It permits quick and convenient measurement of the thickness of the material wherever a flat surface slightly more than 1in. in diameter can be found. The instrument, which weighs 7½ lb., consists of a small indicator in a cast aluminium cabinet, and a 0·5 lb. gauge head connected to the cabinet by cable. When the face of the gauge head is held in contact with the surface of the material to be measured, the thickness can be read directly on an indicating instrument mounted on the front of the cabinet. Because of its light weight, the gauge head can be moved readily to any point on the surface, and the corresponding measurement be conveniently taken.

## Progress of Fuel Research.

THE Department of Scientific and Industrial Research issued last week the Report of the Fuel Research Board, together with the Report by the Director of Fuel Research for the year ended March 31st, 1935.* The Report is made the occasion for a review of the progress achieved in the fuel industry during the twenty-five years of His Majesty's reign.

Despite increasing industrial prosperity and rising population, the consumption of coal in Great Britain has fallen from 180 million tons a year in 1910 to 165 million tons in 1934. It is sometimes suggested that this fall is due to the replacement of coal by oil, but the report states that this conclusion is largely erroneous, and that the decrease is due mainly to the increased efficiency of practically every process for which coal is used.

In 1910 about 4¼ million tons of coal were required to produce 2500 million units of electricity, while for the 16,100 million units generated by authorised undertakings in 1934, only 11·4 million tons were necessary. If the efficiency of production of electrical power had remained the same, 29 million tons of coal would have been used in 1934. An overall thermal efficiency exceeding 27 per cent. has now been obtained in large installations, and further major advances in this direction cannot be expected. Incidentally, it may be stated that the capacity of individual boilers has been raised from 20,000 lb. or 30,000 lb. to 300,000 lb. of steam per hour, and an efficiency exceeding 90 per cent. has been attained in this section of the plant.

The gas industry has also made great advances, and in the period under review the gas supplied by all authorised gas undertakings in Great Britain increased from 178,000 million cubic feet in 1910 to 295,300 million in 1934, while in the same period the coal used only increased from 15·1 to 17·1 million tons a year. If the efficiency of the process of gas manufacture had remained stationary throughout the period an additional 7·9 million tons of coal would have been needed by the industry in 1934.

The coke-oven industry is closely associated with the iron and steel industries, whose coal requirements have fallen by some 15 million tons a year. A considerable proportion of this decrease is due to reduction in the amount of pig iron produced, but it is claimed by the British Iron and Steel Federation that since 1923, largely from the application of the results of research, £4,500,000 per annum has been saved in the cost of fuel. This figure indicates broadly that about 6 million tons less coal were necessary in 1934 than would otherwise have been the case.

The economies in the use of coal in furnaces have been secured largely by burning it in a form that enables it to be fed at a controlled rate into the combustion space. The greatly increased use of mechanical stokers and of pulverised fuel has given to coal and coke a large measure of the flexibility possessed by fluids such as oil and gas. The use of pulverised fuel has increased in the last five years from 2¾ million tons per annum to over 4½ million tons. Pulverised fuel is used for many purposes and there has lately been a marked expansion in its application to metallurgical purposes, which include heating and reheating billets, smelting and melting, annealing and copper refining. It is of interest to record that at the end of 1933 the first plant for supplying coal ready pulverised was installed by a colliery in Yorkshire, and that pulverised coal of a standardised calorific value is now being offered from a plant in the London area for delivery in tank wagons to small consumers.

In the last eight years the amount of coal cleaned has risen from 51·4 million tons, or 20 per cent. of the total coal raised, to 87·5 million tons a year, or 40 per cent. of the total. The notable advances that have been made in cleaning coal, both by wet and by dry processes, have resulted in a reduction in the amount of inert material that is transported from the collieries, and handled, as clinker and ash, after the coal has been burnt; at the same time they have increased the difficulties of disposing of the dirt at the collieries. Future improvements leading to increased economy in the use of fuel, the Report states, will depend more and more on the selection of the most suitable coal for the particular purpose required, and pretreatment of the coal before its final combustion will become of increasing importance. The pretreatment starts at the collieries, where the coal is graded and cleaned as required. The grading may consist of sizing alone, or may include blending the coal from different seams or the separation of the coal from one seam into different portions.

Good progress is reported in the National Coal Survey, which must form the foundation of future development in the use of coal. This work is being carried out in nine laboratories situated in the principal coalfields. The object of the Survey is the examination of the coal seams as they occur in the ground and the various grades of coal as they are prepared and marketed by the different collieries. The results of the Survey are showing that in practically all the British coalfields there are seams containing less than 2 per cent. of ash. In many cases a still higher degree of cleanness can be attained.

In connection with the preparation of coal for the market, good progress has been made at the Fuel Research Station with the development of methods of cleaning fine coal, and the clarification of washery water leading to economy in the use of water and the prevention of river pollution. A new dry cleaning process is being developed in which the unwanted dirt is separated from the coal by jets of air. Problems in connection with the mechanical breaking down of large coal to graded sizes suitable for particular purposes are being investigated.

In connection with the production of motor spirit and lubricating oil from home sources, researches have been continued into the principles underlying the hydrogenation of coal and the hydrogenation cracking of tars and tar oils. The development of these processes is being studied in technical-scale plant in order to obtain sufficient of the motor spirit and oils to test them under practical conditions. The motor spirit is being examined under service conditions. The most important item in this field has been the design and erection of a plant capable of treating about 300 gallons of tar per day, together with the distillation and refining plant required to deal with the spirit produced. It has been found that the technique of hydrogenation does not necessarily require high pressures and thanks to increasing knowledge of catalysts a process has been worked out on a semi-commercial scale at the Fuel Research Station for treating, at atmospheric pressure, acids present in coal tar from gasworks and coke ovens to obtain motor spirits such as benzine.

Considerable progress has been made in the improvement of burners for pulverised fuel furnaces towards overcoming the difficulties of burning low volatile coal, such as some South Wales coal, in furnaces with restricted combustion spaces. Two of these new burners are being manufactured by commercial firms under licence, and with one of them—the "Grid" burner—good results have been obtained in a Lancashire burner with a coal containing as little as 15 per cent. of volatile matter. A satisfactory solution has also been obtained to another practical problem presented in the burning of pulverised fuel. In pulverised fuel firing the distribution of the coal particles moving along a pipe or conduit in a stream of air is not uniform as regards the concentration or the size of the particles, so that dividing the stream into equal parts to supply two or more burners from a common stream is extremely difficult. Moreover, fluctuations occur—for reasons that are not fully understood—in the distribution, necessitating frequent adjustment of the burners to a varying supply of coal and air. A study has been made of the problems involved, and the difficulties have been overcome by a device that is at once simple and efficient.† It appears also that the device can be adapted to other purposes. With slight modification it can be used for sampling, where a small proportion of material must accurately represent the bulk; or, on the other hand, the flow of material can be reversed, and the device will then intimately mix the material fed to it from separate streams. In some commercial installations, where they have been tried, these distributors have led to a reduction in the number of boilers necessary to supply the required load, and to considerable saving in labour and fuel through the better control made possible by their use.

The carbonisation of coal is being studied on a works scale in three types of retort, viz., in a setting of horizontal retorts, in narrow vertical brick retorts, and in chamber ovens. Considerable interest attaches to a modified method of operating horizontal retorts, which has been developed at the Fuel Research Station. It has long been the practice to introduce steam into vertical retorts during carbonisation, but certain practical difficulties prevented this being done in horizontal retorts. The Report states that a successful method has now been evolved at the Station and the results show that the output of gas can be increased 8 to 10 therms per ton of coal carbonised, *i.e.*, the thermal yield of gas produced can be increased by about 10 per cent. at very slight extra cost. As nearly 7,000,000 tons of coal a year, *i.e.*, half the coal used in gasworks in this country, is carbonised in horizontal retorts the potential value of this work to the gas industry is very great. Several large gas companies have adopted the modification in their works.

* The Report is published by H.M. Stationery Office, price 3s. 6d. net.

† This device was described in our issue of October 4th, 1935.

## CONTRACTS AND ORDERS.

*The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.*

HARLAND AND WOLFF, Ltd., have received from the Belfast Harbour Commissioners an order for a twin-screw oil-electric tug and tender, which will also be equipped for fire and salvage work. The order for the fire and salvage equipment has been placed with Merryweather and Sons, of Greenwich, and includes a Merryweather high-lift three-stage electrically driven centrifugal fire pump capable of delivering 2000 gallons per minute and of throwing a single jet to a height of 200ft., a delivery head with six outlets for the attachment of delivery hoses, and a 5in. "fire monitor."

## CATALOGUES.

LEAD WOOL COMPANY, Ltd., Snodland, Kent.—A booklet on pipe jointing with "Lead Wool."

INTER COUNTIES, Ltd., 10, The Boltons, London, S.W.10.—"The Railplane System of Transport."

NEWBURY DIESEL COMPANY, Ltd., Newbury.—Particulars of the "Sirron" high-speed Diesel engines.

CAXTON WOOD TURNERY COMPANY, Market Harborough.—A leaflet on handles and wood turnery for all trades.

A. REYROLLE AND CO., Ltd., Hebburn-on-Tyne.—Leaflet No. 990 of self-contained electric sterilising cabinets.

CROFTS (ENGINEERS), Ltd., Thornbury, Bradford.—Catalogue C.F.335 on flexible and many other types of couplings.

SUFFOLK IRON FOUNDRY (1920), Ltd., Gipping Works, Stowmarket.—A leaflet on "Sifbronze" welding rods.

RENOLD AND COVENTRY CHAIN COMPANY, Ltd., Didsbury, Manchester.—An illustrated brochure of roller chain drives.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway.—A new 976-page book entitled "Insulation Material," containing price lists and illustrations of a large number of the firm's products of the smaller types, such as wiring and lighting fittings, bells, telephones, fans, switches, small instruments, &c.

A FILM ON TIN.—On December 3rd a film entitled "Magie du Fer Blanc" was shown for the first time in this country at the Polytechnic Extension, Little Tichfield-street, W.1, under the auspices of the International Tin Research and Development Council. The parts of the film showing the various processes in making tin plate and forming tin containers are particularly interesting. Much of the remainder of the film is devoted to scenes of conveyors and large numbers of tins in stacks, which, although somewhat impressive, convey little useful knowledge. The fishing, orchard, and mountain scenes are particularly well taken and relieve a certain monotony which is apt to creep into films of this type. Although we were a little disappointed by the rapid manner in which several obviously interesting machines were quickly passed over, it must be remembered that the primary object of the film is publicity and as such the picture is well worth seeing.

## The Development of Coal Hydrogenation.*

By KENNETH GORDON.

(*Concluded from page 578.*)

LARGE-SCALE DEVELOPMENT AT BILLINGHAM.

AT the end of 1932 the research programme which had been carried out after the signing of the I.H.P. Agreement had reached fruition. Vastly improved designs were available, based on our own experience allied with that of our associates in the I.H.P.

Special facilities existed at Billingham which enabled us to put forward an estimate for a plant to manufacture 100,000 tons per year of petrol from coal at a capital cost of £2,500,000. Immediately the British Hydrocarbon Oils Production Bill was announced in July, 1933, the I.C.I. announced that they had sanctioned the building of this plant. As the scheme developed, it became apparent that the output could be increased over the originally decided figure. Further improvements in catalysts gave us some reserve capacity in the liquid and vapour phase sections of the hydrogenation plant. It was therefore decided to increase the plant capacity by tar hydrogenation. The necessary additions to the plant for the reception, storage and distillation of creosote oil and low-temperature tar were decided on, and the capacity of the plant brought up to 150,000 tons per year of petrol. This increased the capital requirement to £3,000,000. The value of the existing plant used is £2,500,000, making a total of £5,500,000. This is substantially more than would be required for an entirely new plant of similar output.

Contracts have been made with tar distillers for the supply of creosote oil, and with low-temperature carbonisation interests for the supply of low-temperature tar.

Of our total flow-sheet output of 150,000 tons per year, approximately 10,000 tons is derived from low-temperature tar, 40,000 tons from creosote oil, and 100,000 tons from coal. Should the price of tar products increase so that it is no longer profitable to utilise them for hydrogenation, the output will be made entirely from coal by small adjustments to the plant.

The hydrogenation of tar products in a plant primarily designed for coal hydrogenation has both technical and economic advantages. Tars are very conveniently processed by using them to make up the coal paste; troubles due to the presence of solids, to instability, and to the corrosive properties of tar, are thus eliminated. The size of plant enables operating costs to be lower, and the credits for tar therefore much higher than would be the case for a plant using tar only. As we have said, the flexibility of the plant enables the quantity of tars consumed to be adjusted according to their market price.

The building of the plant at Billingham involved a very large increase in the staff and labour, and made severe demands upon the workshops, drawing-office, and similar facilities at Billingham. The staff and labour rose from an average of 7000 in early 1932 to 13,600 at the peak of the construction period, and is now 9500. The present increase due to petrol production is about 2000, which includes all hydrogen production, services, repairs, and alterations, research, and administration. This number will probably be reduced when steady running is achieved and is substantially greater than would be necessary for an independent works not undertaking such a heavy research programme as Billingham, and making most of its hydrogen from hydrocarbon gases instead of from coke. The capacity of the workshops at Billingham, where all our high-pressure valves and other fittings are made, was increased by operating them continuously on shift. Four-shift operation, giving an average of forty-two working hours per week, was employed in the workshops, with mutual satisfaction to ourselves and to the men. It was decided to add a new shop for handling heavy tubes. For the petrol plant very large numbers of very heavy high-pressure tubes, frequently in alloy steel, had to be cut, bent, and machined, and it was also decided to employ welding to an extent hitherto unprecedented in high-pressure work. This tube shop, as it is called, complete with its butt resistance welding machine and annealing furnace, was put into operation only twenty-six weeks after starting on the programme. The first plant building to be finished was the maintenance building where the heavy forgings are assembled. The first converter forging was delivered here in April, 1934.

It was decided to complete the vapour phase converters first and operate them on a light distillate oil made from creosote oil. Liquid phase converters were next to be started with the heavy residues from creosote oil, and, lastly, the coal hydrogenation units themselves. In this way the operation of coal hydrogenation units, when they were once going, would not be interrupted by failure or difficulties in subsequent parts of the process.

Storage facilities were sufficiently advanced to receive the first consignment of creosote oil in August, 1934. The creosote distillation unit was started up in November, 1934. Sections of the plant were put up to pressure with hydrogen in January, 1935, and the first vapour phase hydrogenation unit was sufficiently advanced to permit of lighting the burners of the preheater in the same month, seventeen months after sanctioning expenditure on the plant.

Oil was first injected for hydrogenation on February 7th, and production has continued without interruption from that time. The first coal hydrogenation units were ready for operation at the beginning of April, but it was decided to make some alterations to avoid certain difficulties which had been experienced in starting the liquid phase hydrogenation unit.

Coal was injected for the first time in June, and since then the output has steadily increased, in spite of interruptions from time to time to make minor modifications of the sort usually required in a new plant. We expect to attain full flow-sheet output before the end of this year.

The stock position was by the beginning of April sufficiently secure to commence regular shipment of finished petrol to the oil companies, and the first boat left on April 9th. From that time, shipments have been made regularly.

Most despatches have been made by water, and the

* The Institute of Fuel—November 22nd.

petrol is taken away in tankers of 1000 tons capacity from the special jetty built for the purpose at Billingham.

The plant at Billingham is deliberately laid out so as to provide the maximum flexibility for additions and alterations. When the whole plant has run long enough to determine the various limitations to output, these will be eradicated step by step, and doubtless the Billingham plant will finally have an output considerably in excess of the present one.

The hydrogen supply is derived from coal *viâ* coke and the water-gas process.

The hydrocarbon gases formed as a by-product consist of methane, ethane, propane, and butane. They are now burned under the boilers, so that although they are not wasted the most economic use is not made of them. A plant is being erected at Billingham for the manufacture of hydrogen from these gases by treatment with steam in the presence of catalysts. This process was worked out originally by the I.G. and the Standard Oil Company. It provides the latter with the hydrogen for their hydrogenation plant in America. The Billingham unit will be ready early next year, and all future extensions and other plants built for hydrogenation will probably obtain the major part of their hydrogen requirements from similar units.

These hydrocarbon gases give us in this country a supply equivalent to the natural gas of America and other countries with oilfields.

Part of this gas is already in commercial use. The butane is separated, liquefied, and bottled and sold to the Calor Gas Distributing Company, who are developing the use of butane for domestic purposes in places where coal gas is not available.

Phenol, cresol, and high homologues are available in substantial quantities in the crude product from coal, but are not yet worked up.

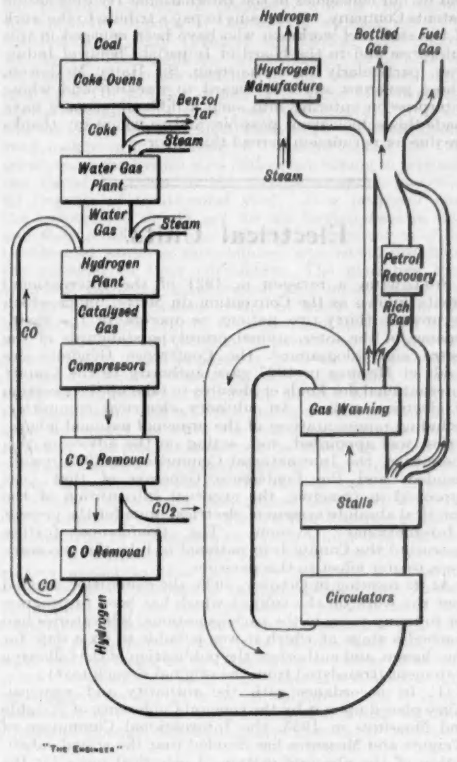



FIG. 10—*Flow Diagram of Hydrogen Production and Treatment of Hydrogenation Plant Gases.*

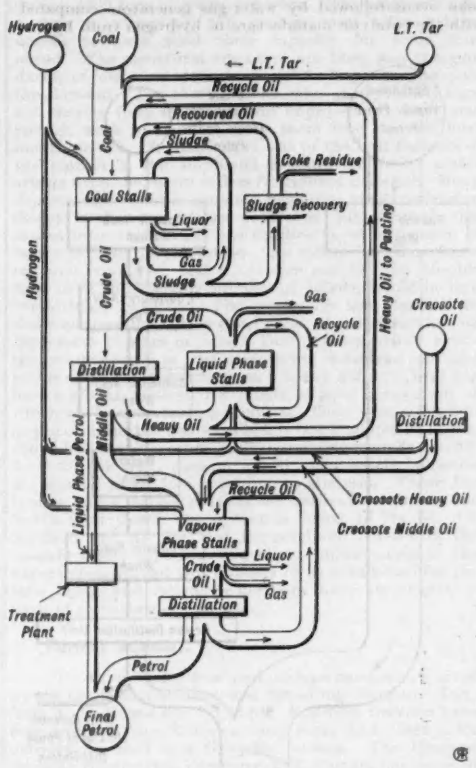



FIG. 11—*Flow Diagram of Billingham Plant for Hydrogenation of Coal, Creosote Oil, and L.T. Tar.*

## DESCRIPTION OF THE BILLINGHAM PETROL PLANT.

The hydrogen producing process used at Billingham is shown in Fig. 10. The coke is made in coke ovens and transferred directly to the water-gas plant. The water-gas is purified from sulphur and treated with steam in the presence of a catalyst to give catalysed gas, which is a mixture of hydrogen, carbon dioxide, and a small amount of carbon monoxide. This gas is compressed and purified from carbon dioxide by scrubbing with water at 50 atmospheres pressure, and from carbon monoxide by scrubbing with copper solution at 250 atmospheres pressure. The gas flows through duplicate high-pressure mains to the petrol plant, where it enters the suction of the circulating machines. These are designed to operate with 230 atmospheres suction pressure and 265 atmospheres delivery pressure. The circulating hydrogen becomes impure partly through accumulation of nitrogen from the make-up gas, and partly through accumulation of methane, ethane, propane, and butane formed in the process. Part of these gases is removed by solution in the products themselves, and is recovered upon release of pressure. The purity of the circulating gas is finally controlled by scrubbing with oil at full pressure. The hydrocarbon gases readily dissolve in oil, and are recovered upon release of pressure. Fortunately, nitrogen is more soluble than hydrogen in oil, and thus is similarly removed from the system.

The general flow-sheet of the process as worked at Billingham is shown in Fig. 11. It will be seen that low-temperature tar is used as part of the pasting oil. The creosote oil is distilled and the heavy fraction hydrogenated in the liquid phase, whilst the light fraction passes directly to the vapour phase. It is possible that later we will use the whole of the creosote oil as pasting oil, since it is apt to contain traces of impurities, which give trouble in the vapour phase part of the plant.

The Chance process is used for making the clean coal required at Billingham. This process depends for its action on floating the raw coal on a suspension of sand in water. It is necessary first of all to remove all dust and fine particles of coal, which is effected by air elutriation, followed by screening. The subsequent sand and water flotation process is arranged to operate in two stages. First the coal is separated into refuse of low carbon content and a moderately clean coal of about 7 per cent. ash content. This partly clean coal then passes to the second stage, where separation is made into clean coal with not more than 2½ per cent. ash and middlings with 15 per cent. ash—Fig. 12. The coal cleaning plant is built adjacent to the boiler installation at Billingham so as to use the coal handling facilities already installed there. The fines and middlings from the coal cleaning plant pass directly by band conveyors into the main boiler plant, which is a powdered fuel installation. The clean coal is taken by truck to the hydrogenation plant, where it is stored in bunkers which contain two days' supply.

The clean coal passes to the grinding mills *viâ* weighing machines, which are contrived to deliver coal, pasting oil, and catalyst in the required proportions. These are fed simultaneously into the grinding mills, which both grind up the coal and mix it with pasting oil. The coal "paste" contains 50 per cent. coal and is quite fluid and reasonably stable.

The injectors for delivery of coal paste against the required pressure of 250 atmospheres are, in accordance with previous practice, hydraulically operated. The water for power purposes is supplied from centrifugal pumps delivering at 40 atmospheres pressure.

The coal paste then passes to the coal hydrogenation units, which are similar in design to the other units used for heavy oil and vapour phase hydrogenation. The coal paste and hydrogen are mixed together and are heated up to reaction temperature first in heat exchangers, and, secondly, in gas-fired preheaters. The coal, oil, and hydrogen then pass together through the converters in series. On leaving the last converter the gases and vapours are separated from the residual heavy oil which contains the ash and unconverted coal. The heavy residual oil is let down in pressure separately, part of it is used for making up the coal paste and part treated for recovery of oil and solid coke. The gases and vaporised oils go to the heat exchangers and coolers. The liquid oils are separated under pressure and the gases go back to the circulators, after washing out any excess hydrocarbon gases in the gas washing plant.

The converters, heat exchangers, and preheaters of all the units are arranged in one line on heavily piled founda-

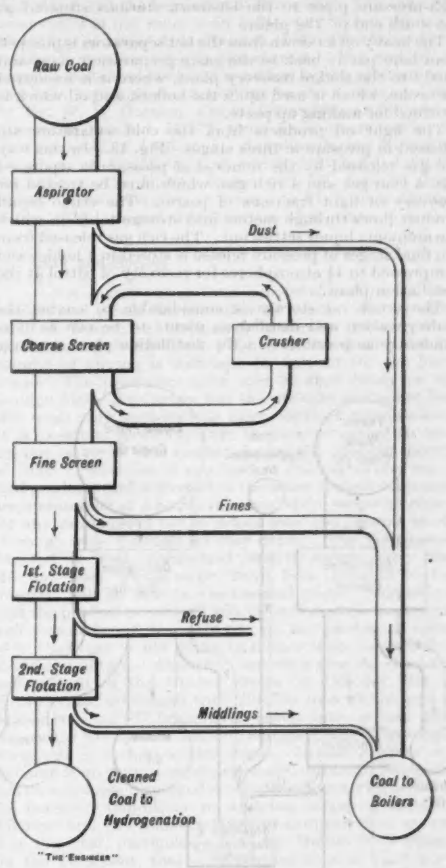



FIG. 12—*Diagram of Coal Cleaning Process.*

tions. In each stall, as each unit is called, the converters, heat interchangers, and interconnecting piping, which are at elevated temperatures, are separated from the rest of the plant by a high brick wall, which acts as a screen in the event of fire. This wall is on the west side of the plant, which is open to the east. This is very convenient for maintenance work, but access is not otherwise permitted to the space in front of the operating stalls.

The general arrangement of each stall (see page 586, *ante*) follows the line diagram given in Fig. 6, *ante*. The heat interchangers, catchpots, converter forgings, gas-fired preheaters, and coolers for the stalls are all interchangeable.

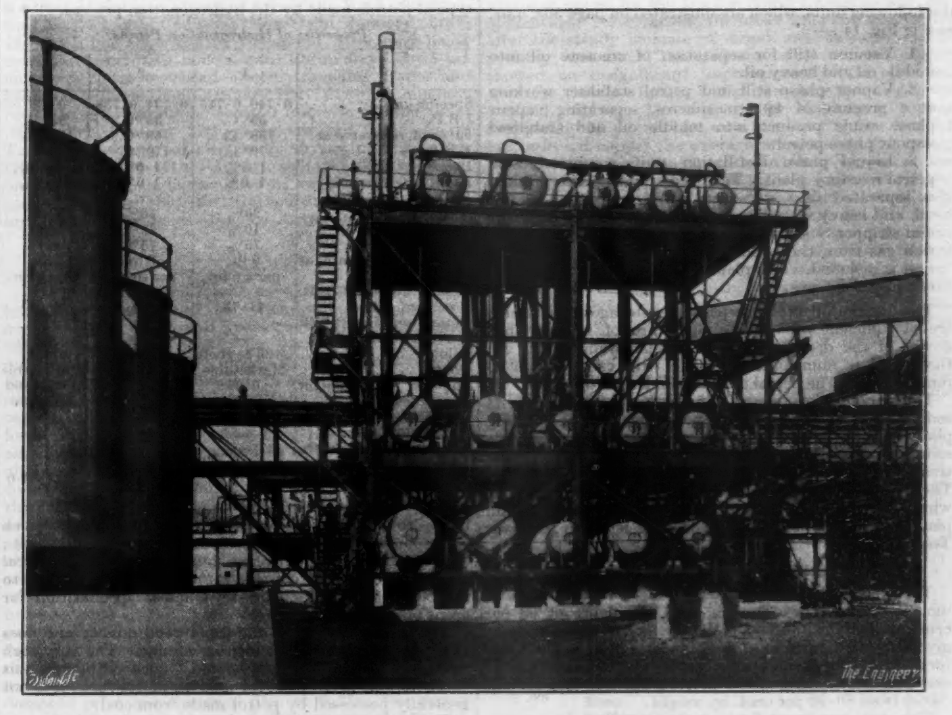



FIG. 13—*Plant for Release of Pressure from Products in Three Stages.*

A Titan crane is arranged to convey the converters and other heavy forgings to the maintenance building, where repairs are carried out. The converters are designed so that the heavy and expensive main forgings can rapidly be transferred to a new set of internal parts.

Each pair of stalls has a roomy control room, which contains all the instruments and all valves required during ordinary running. From the control room it is possible, not only to carry out the ordinary running of the stall, but also in case of emergency to isolate the unit from the rest of the plant and to blow down the pressure to vessels kept filled with carbon dioxide against this contingency. This arrangement of control rooms is extremely convenient and also affords a high degree of safety to the operatives.

The crude products from the hydrogenation plant are released in pressure at the control room and travel along high-pressure pipes to the let-down stations situated at the south end of the plant.

The heavy oil let down from the hot separators is pumped from here partly back to the paste preparation plant and partly to the sludge recovery plant, where it is separated into coke, which is used up in the boilers, and oil which is returned for making up paste.

The light oil products from the cold separators are released in pressure in three stages—Fig. 13. In this way the gas released by the removal of pressure is separated into a lean gas and a rich gas, which must be treated for recovery of light fractions of petrol. The crude liquid product flows through meters into storage tanks in which the ammonia liquor settles out. The rich gas released from the final stages of pressure release is stored in a holder and compressed to 4½ atmospheres for recovery of petrol at the distillation plant.

The crude oil storage is considerable to enable the hydrogenation and distillation plants to be run as independently as possible. In the distillation plant we have

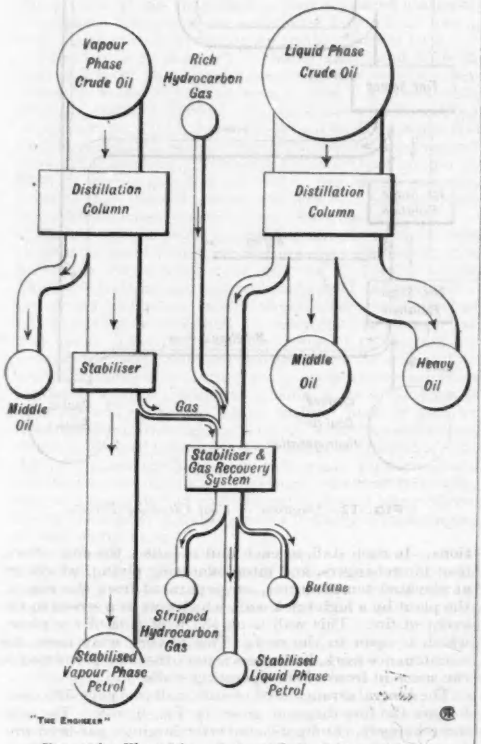



**FIG. 14**—*Flow Diagram for Oils and Gases in the Distillation Unit.*

the following units, which are illustrated on page 568, *ante*, and in Fig. 14 :—

1. Vacuum still for separation of creosote oil into middle oil and heavy oil.

2. Vapour phase still and petrol stabiliser working at a pressure of 4½ atmospheres, separating vapour phase crude product into middle oil and stabilised vapour phase petrol.

3. Liquid phase distillation unit, combined with petrol recovery plant. The crude liquid phase product is separated into stabilised petrol, naphtha, middle oil, and heavy oil. The unit also contains an absorber and stripper to separate the petrol from the compressed rich gas from the pressure release station. A butane unit is included. This plant works at the same pressure of 4½ atmospheres.

The distillation products pass into storage tanks which are of sufficient capacity to take care of routine shut downs of the distillation and hydrogenation units. All the petrol is immediately washed with caustic soda to remove $H_2S$. The petrol is stored under nitrogen.

The vapour phase petrol requires no refining after its soda wash. The liquid phase petrol goes to the treating plant, where it is washed with sulphuric acid and caustic soda and finally re-run. Fig. 15 is the diagram of the treatment and re-run plant, which follows normal practice. The finished petrol is pumped to the final storage tanks, which are about one mile distant from the hydrogenation plant site and adjoin a special loading jetty on the river Tees.

### Efficiency of the Process.

The yield of petrol from coal calculated on an ash and moisture-free basis is greater than the figure of 60 per cent. formerly published. We prefer, however, not to give any new figures until the plant has been in operation for a longer time than at present, and really accurate figures are available. The yield of petrol from tars and tar oils varies from 80–90 per cent. by weight.

The most important figure is the overall coal consumption. On a new plant, in which the major part of the hydrogen requirements would be made by the methane steam process, we estimate that the overall consumption of raw coal would vary from 3·5 to 4 tons per ton of petrol, the exact figure depending upon both the ash and moisture content of the coal, and its suitability for the process. The thermal efficiency is therefore 40 per cent., which compares favourably with 25 per cent. for generation of electric power and 55 per cent. for gasification.

In the Billingham plant the hydrogen is not made from hydrocarbon gases, but from coal *viâ* coke and water-gas. The overall raw coal consumption at Billingham for the 100,000 tons per year of petrol made from coal is 500,000 tons. This is 5 tons of raw coal per ton of petrol, and this higher figure is primarily due to the lower efficiency of coke ovens followed by water-gas generators compared with the catalytic manufacture of hydrogen from hydro-

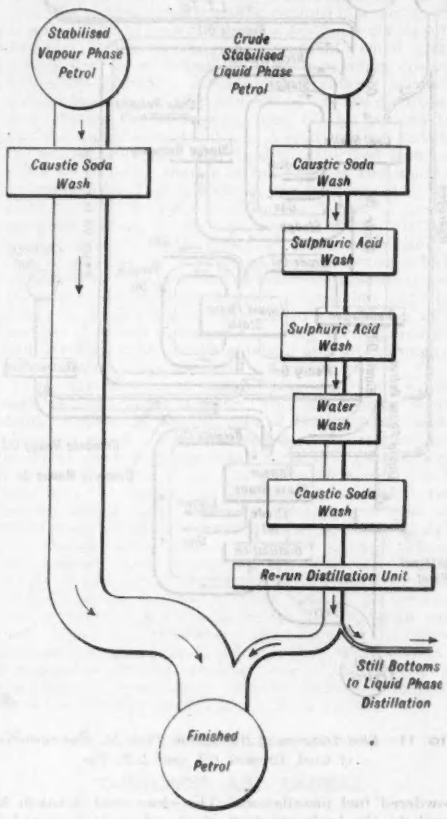



**FIG. 15**—*Refining Treatment of Hydrogenation Plant Petrol.*

carbon gases, and is partly compensated for from the financial point of view by credits for the tar, benzol, and gas made as by-products. A further 100,000 tons per year of coal are used in making the hydrogen and power required for the hydrogenation of creosote oil and tar, so that the total additional coal consumption due to the petrol plant is 600,000 tons per year. The total coal consumption at Billingham, including that required for chemical manufacture, is between 1½ and 1½ million tons per annum.

### Quality of Product.

The following table gives the essential properties of typical petrols made by the hydrogenation process. "1" refers to a petrol obtained directly from coal, which corresponds to current specifications for No. 1 spirit; "2" indicates a vapour phase petrol made up to a typical ethyl specification with lead; "3" is a spirit made to comply with the Air Ministry's latest specification for spirit of 87 octane number.

*Properties of Hydrogenation Petrols.*

| | 1 | 2 | 3 |
|---|---|---|---|
| Specific gravity | 0·740–0·745 | 0·734–0·738 | 0·730 |
| I.B.P. | 35° C. | 35° C. | 35° C. |
| 90% vol. recovered at | 158° C. | 160° C. | 150° C. |
| F.B.P. | 170° C. | 170° C. | 165° C. |
| Residue | 1·0% | 1·0% | 1·0% |
| Loss | 1·0% | 1·0% | 1·0% |
| % Distillation + loss— | | | |
| At 70° C. | 20% | 19% | 21% |
| At 100° C. | 40% | 40% | 50% |
| At 140° C. | 75% | 75% | 87% |
| Reid vap. pressure at 100° F. | 9 lb. per sq. in. | 9 lb. per sq. in. | 7 lb. per sq. in. |
| Octane number C.F.R. motor method | 71–73 | 80 | — |
| Octane number C.F.R. aviation method | — | — | 87 |
| Colour | +25 Saybolt | Red | Blue |
| Odour | Marketable | Marketable | Marketable |
| Sulphur, % by weight | 0·05 | 0·01–0·02 | 0·01–0·02 |
| Doctor test | Negative | Negative | Negative |
| A.S.T.M. copper strip corrosion test | " | " | " |
| Gum, pyrex dish without air jet (mgm. per 100 ml.) | 2·0 | Up to 3·0 | Up to 3·0 |

The petrol made is of uniformly good quality and does not give any special difficulty in refining. The very high volatility figures will be noted, since although this characteristic is essential for modern motor fuels, it is not generally possessed by petrol made from coal.

In the last two years we have not had much time to give any attention to the problem of producing Diesel oil from coal. In an earlier paper we described a reasonably good Diesel oil. The only objection to this material was that it was rather lower in viscosity than the material commonly employed. There is no insuperable difficulty in producing a satisfactory oil.

The heavy oil obtained from coal is perfectly suitable for use as fuel oil without any further treatment. Fuel oil could be produced at a much lower cost than petrol. We have had no time to give any attention to the problem of lubricating oil manufacture.

---

In the body of this paper I have made acknowledgment of the work done by the original inventor of the process and by our colleagues in the International Hydrogenation Patents Company. It remains to pay a tribute to the work of the staff and workmen who have been engaged in this enterprise and to the board of Imperial Chemical Industries, particularly their chairman, Sir Harry McGowan, whose generous spirit in regard to research and whose enterprise in entering into such a difficult venture have made this achievement possible, and to whom my thanks are due for permission to read this paper.

## Electrical Units.

Following a revision in 1921 of the International Treaty known as the Convention du Mètre, under which at present thirty-two nations co-operate in the maintenance of the international prototype standards of the metre and kilogramme, the Conférence Générale des Poids et Mesures in 1927 gave authority to the Comité International des Poids et Mesures to take up the question of electrical units. An advisory electrical committee, including representatives of the principal national laboratories, was appointed, and, acting on the advice of this committee, the International Committee in 1933 recommended, and the Conférence Générale of that year approved in principle, the eventual substitution of the practical absolute system of electrical units for the present "International" system. The Conférence further instructed the Comité International to take the necessary steps to give effect to this decision.

At its meeting in October, 1935, the committee decided that the work on the subject which has been in progress for so many years in the various national laboratories had reached a stage at which it was possible to fix a date for the change, and authorised the publication of the following statement (translated from the original French text) :—

(1) In accordance with the authority and responsibility placed upon it by the General Conference of Weights and Measures in 1933, the International Committee of Weights and Measures has decided that the actual substitution of the absolute system of electrical units for the international system shall take place on January 1st, 1940.

(2) In collaboration with the national physical laboratories, the Committee is actively engaged in establishing the ratios between the international units and the corresponding practical absolute units.

(3) The Committee directs attention to the fact that it is not at all necessary for any existing electrical standard to be altered or modified with a view to making its actual value conform with the new units. For the majority of engineering applications the old values of the international standards will be sufficiently close to the new for no change, even of a numerical nature, to be required. If for any special reason a higher precision is necessary, numerical corrections can always be applied.

(4) The following table gives a provisional list of the ratios of the international units to the corresponding practical absolute units, taken to the fourth decimal place. Since differences affecting the fifth decimal place exist between the standards of the international units held by the various national laboratories and also because all the laboratories which have undertaken determinations of the values of their standards in absolute measure have not yet obtained final results, the Committee does not consider it desirable for the present to seek a higher precision. At the same time it hopes that it will be possible to extend the table of these ratios with a close approximation to the fifth decimal place well before the date fixed for the actual substitution of the practical absolute system for the international system.

| | | | |
|---|---|---|---|
| 1 Ampère international | = | 0·999 9 | Ampère Absolute |
| 1 Coulomb | = | 0·999 9 | Coulomb |
| 1 Ohm | = | 1·000 5 | Ohm |
| 1 Volt | = | 1·000 4 | Volt |
| 1 Henry | = | 1·000 5 | Henry |
| 1 Farad | = | 0·999 5 | Farad |
| 1 Weber | = | 1·000 4 | Weber |
| 1 Watt | = | 1·000 3 | Watt |

## PERSONAL AND BUSINESS ANNOUNCEMENTS.

Specialloid Ltd. informs us that Mr. A. W. Roebuck, manager for the northern counties, has been promoted to the position of sales manager for Scotland, Ireland, and the northern area.

Mr. James Herbert Gold, who in 1933, upon the reconstruction of the board of Blackstone and Co., Ltd., oil engine manufacturers, of Stamford, which followed the severance of the company from Agricultural and General Engineers, Ltd., was appointed director and chairman of the company, has now, upon the discharge of the debenture issued to the company's bankers and the acquisition by other interests of the whole of the capital of the company, retired from these positions.

---

The Manufacture of Rolls for Rolling Mills.—We are asked to state that the third illustration in the article bearing the above-named title in last week's issue illustrates a 35½-ton roll in a Churchill roll-grinding machine and not in a lathe as stated.

# Markets, Notes and News.

**The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.**

### Steel Trade Problems.

Several meetings which may have important consequences for the iron and steel trades are taking place this week. Representatives of the Continental steel makers are meeting representatives of the British Iron and Steel Federation in London, and it is understood that the principal subject of discussion will be the method by which the imports of Continental material are to be controlled. To-day (Friday) the British steel makers will meet at Harrogate, and it is assumed that, in addition to discussing matters relating to the new British Iron and Steel Corporation, which is to come into existence at the beginning of next year, the question of prices will be under review. The talks with the Continental steel makers will also concern the functions of the Corporation, as the British steel makers are hoping to persuade the Cartel to agree to the new organisation handling all imports of Continental steel. It is proposed that the Corporation should pay for the foreign steel *en bloc*, and then re-sell it to the existing representatives of the Continental works in this country, who would distribute the material to their customers. The plan has been criticised as being cumbersome and unnecessary, but the British steel makers desire to know to whom the imported material will be consigned and also hope to be able to advance the prices of imported steel. There are several points which apparently have not yet been fully discussed, including the question of the profit, if any, which the Corporation should be allowed to make upon the transaction, and whether the new organisation is to have the power to select the consumers who are to be supplied. The recent transaction by which the Federation purchased several thousand tons of semi-finished steel above the agreed quota for the British market in order to relieve the scarcity has caused some irritation to the Continental makers. The British Federation resold the material to consumers at a price which it is reported yielded a handsome profit, and when the Continental makers awoke to this fact they resented a situation which, in effect, resulted in their subsidising their British competitors. If an arrangement is reached with the Continental makers by which the Corporation will buy and sell the imported steel, it is possible that this may make matters easier at the Harrogate meeting. The use of the Corporation by individual firms as a central selling organisation for export is to be voluntary, and it is not yet certain to what extent this method of selling will find adherents amongst the steel makers and the re-rollers.

### Pig Iron.

The volume of business in most branches of the pig iron market shows signs of declining, although the change is more noticeable in the weights of the individual orders coming to hand than in the actual number. The demand usually becomes restricted over the period from the beginning of December to the middle of January, owing to the reluctance of all traders to carry heavy stocks at the end-of-the-year's stocktaking. The situation, however, is entirely satisfactory to the manufacturers, since they have an important tonnage of contracts in hand, some of which extend into the second half of next year. On the North-East Coast the makers have sold as much iron as they can undertake to deliver until March, 1936. Consumers appear willing to extend their purchases even beyond that date, but the producers make no secret of the fact that they anticipate that the costs of production will have risen by then to a point which will make an advance in prices necessary. Specifications against contracts in hand continue to reach the works at a rate which taxes their resources. Business in Midland irons has been well maintained since the advance in prices, and in this market also the approach of the end of the year is marked by some decline in the volume of orders. Nevertheless, the demand is sufficient to absorb the current production and to necessitate substantial withdrawals from stocks. The depletion of the reserves in the hands of the ironmasters is attracting some attention, and it is suggested that if the present rate of consumption is maintained more furnaces will have to be put into operation in this district. Lately there has been one of the periodical improvements in the demand for forge iron, but the market requirements of this description are still disappointing. In Lancashire consumers are understood to have covered their requirements before the recent advance occurred, and for the past week or two comparatively little new business has been transacted. The way in which specifications against contracts are reaching the local works, however, has created the impression that some consumers will need to enter the market again before many weeks have elapsed. In Scotland consumption has strengthened of late and the stocks of pig iron have been materially reduced. In this district also there is talk of new furnaces being started up in the near future. Business in hematite has been active, but the producers are so heavily sold forward that they have comparatively little iron to offer. Consumers, however, are prepared to enter into extensive forward commitments, as it is believed that an advance in prices will shortly be made.

### Scotland and the North.

During the past week a heavy tonnage of new orders has been placed with the Scottish iron and steel works. Practically all departments of the trade have shared in this business excepting, perhaps, the bar iron makers, who are finding the demand for their better-class products rather slow. Their position has improved over the past few months; but, chiefly owing to the sale of the cheaper grades, particularly the No. 3 and No. 4 bars, which have displaced to a great extent imported Belgian material. The situation at the steel works has not materially altered and could scarcely be better. Almost without exception the makers can see their way to keep their works busily engaged over the first quarter of next year. New orders for ships will provide fresh work for the mills employed on this class of material, and these with the orders already in hand will tax productive resources. Steps are being taken to increase the country's production of billets and Colvilles are laying down plant at the Glengarnock Works, capable of producing 2500 tons of billets per week. The plant will take a year to complete. At present most billet makers appear to have filled their capacity for some time ahead. The structural engineers are busy and the producers of joists and sections are not finding it easy to meet the demand. The sheet makers, who until recently were not sharing fully in the general improvement, have now enough work in hand to keep them busy for the next month or two. In Lancashire one of the best features of the market is the improved demand for boiler plates arising from the recent orders for railway material. Many departments of the consuming industries are experiencing delays in delivery against contracts, but although this causes inconvenience, it has resulted in an expansion of business with stockholders. Re-rollers in Lancashire are well employed, and if it were not for the trouble they have in obtaining supplies of billets, would be in a comfortable position. The works on the North-West Coast are meeting with a steady flow of orders and have a big reserve of work in hand. During the past few weeks the requirements of the engineering industries and the motor car makers have been on a heavy scale. There has been a strong demand for billets, a good proportion of which has been for forging qualities. There is no alteration in prices, untested soft steel billets being quoted at £5 10s. d/d in 500-ton lots, other qualities ranging from £5 12s. 6d. for 0·25 per cent. carbon. Acid open hearth varieties are quoted at £6 15s. according to analysis. There has been a fairly active request for malleable iron on the North-West Coast, the quotation being £5 11s. 6d. d/d Sheffield and £5 15s. d/d Birmingham. Recently the manufacturers experienced a slight improvement in the export demand, but this appears to have subsided for the time being and quieter conditions have developed in most of the overseas markets.

### Current Business.

An order for four motor ships has been received by the Goole Shipbuilding and Repairing Company, Ltd., from T. E. Evans and Co., Ltd. Fourteen trawlers have been ordered from Cochrane and Sons, Ltd., Selby, for delivery to Hull and Grimsby owners. The Glasgow Railway Engineering Company, Ltd., Govan, has received an order for railway axles from the Egyptian State Railways. The Skew Bridge at Dockacres, Carnforth, on the London-Carlisle road, is to be replaced by a steel girder bridge, at an estimated cost of £33,400. The Ministry of Transport has made a grant of 75 per cent. from the Road Fund towards the scheme. The Kidwelly Tin-plate Works restarted operations at the beginning of this week, after being idle for fifteen months. The London and North-Eastern Railway bridge over Valley-road, Nottingham, will be replaced by a steel bridge. The new bridge will be 80ft. between abutments and the estimated cost is placed at £28,500, of which the Road Fund will provide 75 per cent. Plant is being installed by Ferro-concrete (Lancs.), Ltd., on the site of a former copper works at Garston, for the manufacture of reinforced concrete products. Cammell Laird and Co., Ltd., Birkenhead, have received an order from the Blue Star Line for the construction of a 12,000-ton refrigerator ship; and Swan, Hunter and Wigham Richardson, Ltd., Wallsend, are to supply a twin-screw motor ship for the Commonwealth and Dominion Lines for Australian trade. The Department of Overseas Trade announces that the following contracts are open for tender:—Indian Stores Department: supply and delivery under an annual rate contract of cast iron pipes and specials to B.S.I. Specification No. 78 (current edition) (New Delhi, January 16th); 400 steel flue superheating tubes and 2700 steel boiler tubes for locomotive boilers, two 10-ton and one 15-ton and two 30-ton overhead electric travelling cranes and spare parts (New Delhi, January 2nd); City of Kimberley, South Africa: supply of abattoir and one chilling plant (Kimberley, January 27th); Government Railways of Tasmania; supply of electrically driven machine tools (Hobart, January 15th); Argentine State Oilfields Directorate: fifty-one induction motors, various ratings, with control gear, switches, &c.; thirteen transformers, circuit breakers, and switches (Buenos Aires, December 26th).

### Copper and Tin.

Lethargic conditions have ruled in the electrolytic copper market and the volume of business has been much less than for several weeks past. The international situation and the tendency for consumers to postpone purchasing, which usually makes itself apparent towards the end of the year, is sufficient to account for the altered situation. Italian efforts to obtain supplies of copper before the proposed drastic sanctions can be brought into force have been the only feature of the market. A fair amount of business is reported to have been transacted, although it is possible that more buying by Continental countries has been attributed to indirect Italian purchases than has actually been the case. The copper producers are in a strong position, inasmuch as they have a substantial tonnage of orders for future delivery which will absorb a good proportion of their output. There has been some talk, however, that the restriction scheme will be relaxed in order to enable some of the companies to increase production. This seems improbable, since the policy of the large producers for some time past seems to have been to dispose of their heavy stocks and much remains to be done in that direction before the position can be considered well balanced. Although the American domestic price has remained firm at 9·25c., the export price has become easier at 8·80c., or about £40 c.i.f. American exports in October totalled 17,200 tons, making 218,729 tons for the ten months of this year. In the standard market prices have been firm, and although there has been a certain amount of realisation, the market easily absorbed the copper offered. In fact, merchants bought freely and appear to take a favourable view of the outlook.... The chief feature of interest in the tin market was the arrival of 1400 tons of Banca tin at the end of last and the beginning of this week. This quantity, however, was not more than sufficient to keep the backwardation at about £10, although it had the effect of promoting a steadier tone in the market. The end of the month's statistics disclosed a rather better position than had been anticipated. According to the figures compiled by Mr. W. H. Gartsen, the visible supply at the end of November totalled 13,577 tons, an increase upon the October total of 1445 tons. Supplies during November are given as 10,632 tons, of which 4465 tons of Straits tin went to the United States and 750 tons to Great Britain. The deliveries amounted to 9187 tons, America taking 4035 tons and Great Britain 1742 tons.

### Lead and Spelter.

A rather easier tone has developed in the lead market and prices have tended to recede. In the early part of December consumers generally restrict their purchases until the New Year and the decline in the volume of buying is sufficient to account for the lower prices. The producers have sold forward freely on the London Metal Exchange, but the arrivals of Empire lead still seem only sufficient to meet contract requirements. It is possible, however, that the market situation may become easier in this respect during the opening months of 1936. Deliveries of raw lead to the manufacturers of lead products and deliveries of the latter to their customers are maintained at a heavy rate, and there seems no reason for any pronounced fall in prices from the present levels, although wide fluctuations may occur. The Continental demand is well maintained and it seems likely that Mexican lead, which might have been brought to this country, will be sent to Continental ports. Suggestions that the production of lead will be increased do not appear well founded, and the attitude of the producers seems to be that they would prefer to reduce their stocks before increasing output. American statistics give the stocks of refined lead in the United States on October 31st as 225,039 tons, compared with 224,732 tons at the end of September.... Comparatively little interest has been evinced in the spelter market, and naturally prices have developed a rather weaker tone. In this country the demand is on only a moderate scale, although lately the galvanisers have displayed a certain amount of interest in the market. Conditions in America, however, are very different and the demand there is stronger than at any time this year, particularly from the Middle West States. On the Continent, too, consumption is on a quite good scale. Although it is reported that negotiations for the revival of the International Zinc Cartel are continuing in a desultory fashion, no steps of importance seem to have been taken. Last week there were some arrivals of Continental spelter and the offer of this metal on the London markets established the carrying rate at 6s.3d. The arrivals of Empire spelter also have been sufficient to meet the rather moderate requirements of the market. For some weeks this has been a distinctly colourless market and so far as can be seen conditions are not likely to alter at any rate until the New Year.

### Non-ferrous Metals Average Prices.

The course of prices in the non-ferrous metal markets during November as disclosed by the official averages issued by the London Metal Exchange was disappointing. Nevertheless, the losses were not heavy, and after the steady increase of recent months some decline possibly was due. The average price for cash copper showed an insignificant improvement of 2d. per ton over the October figure, whilst the three months' price was 3d. higher. The average for electrolytic copper dropped by 7s. 3d. and for wire bars by 10s. 3d.; but for best selected copper the average price was 1s. 2d. better than for the previous month. In the tin market the steadiness of the price of cash tin was indicated by the fact that the average in November showed a loss of only 12s. compared with the previous month, but for three months' tin it was £4 10s. 11d. lower than in October. The fluctuations which occurred in the lead market resulted in a fall in the average price for October of 5s. 5d. for shipment the current month, and of 5s. 6d. for shipment in the third following month, the mean being also 5s. 6d. down. The average price for spelter for shipment the current month dropped 4s. 11d., and for shipment the third following month 6s. on the October figures, the mean being 5s. 6d. down. The following are the London Metal Exchange official average quotations for November:—

| | | | | |
|---|---|---|---|---|
| STANDARD COPPER .. | Cash (mean) .. .. | £35 | 5 | 4⅞ |
| | 3 Months (mean) .. | £35 | 12 | 8¼ |
| | Settlement .. .. | £35 | 5 | 4⅞ |
| ELECTROLYTIC COPPER (mean) .. .. .. .. | | £39 | 12 | 1$\frac{5}{16}$ |
| ELECTROLYTIC WIRE BARS .. .. .. .. | | £39 | 16 | 3½ |
| BEST SELECTED COPPER (mean) .. .. .. | | £39 | 2 | 6 |
| STANDARD TIN .. .. | Cash (mean) .. .. | £226 | 16 | 10¼ |
| | 3 Months (mean) .. | £212 | 18 | 2½ |
| | Settlement .. .. | £226 | 15 | 11$\frac{5}{8}$ |
| LEAD — For shipment the current month .. | | £17 | 18 | 9 |
| LEAD — For shipment the third following month .. .. .. .. .. .. | | £17 | 18 | 8$\frac{5}{8}$ |
| LEAD — Mean .. .. .. .. .. .. | | £17 | 18 | 8$\frac{15}{16}$ |
| LEAD — Settlement .. .. .. .. .. .. | | £17 | 18 | 6¾ |
| SPELTER — For shipment the current month .. | | £16 | 3 | 10$\frac{3}{4}$ |
| SPELTER — For shipment the third following month .. .. .. .. .. .. | | £16 | 7 | 5½ |
| SPELTER — Mean .. .. .. .. .. .. | | £16 | 5 | 7$\frac{1}{4}$ |
| SPELTER — Settlement .. .. .. .. .. | | £16 | 3 | 9$\frac{3}{4}$ |

# Current Prices for Metals and Fuels.

Makers' official home trade prices per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

## PIG IRON.

| | Home. (*D/d Teesside Area*) | Export. |
|---|---|---|
| N.E. COAST— | £ s. d. | £ s. d |
| Hematite Mixed Nos. | 3 10 6 | 3 2 0 |
| No. 1 | 3 11 0 | 3 3 6 |
| Cleveland— (*D/d Teesside Area*) | | |
| No. 1 | 3 12 6 | 3 4 0 |
| No. 3 G.M.B. | 3 10 0 | 3 1 6 |
| No. 4 Forge | 3 9 0 | 3 0 6 |
| Basic (*Less 5/– rebate*) | 3 10 0 | — |
| MIDLANDS— | | |
| Staffs.— (*Delivered to Black Country Station*) | | |
| North Staffs. Foundry | 3 15 0 | — |
| „ „ Forge | 3 10 0 | — |
| Basic (*Less 5/– rebate*) | 3 15 0 | — |
| Northampton— | | |
| Foundry No. 3 | 3 12 6 | — |
| Forge | 3 7 6 | — |
| Derbyshire— | | |
| No. 3 Foundry | 3 15 0 | — |
| Forge | 3 10 0 | — |
| SCOTLAND— | | |
| Hematite, f.o.t. furnaces | 3 13 6 | — |
| No. 1 Foundry, ditto | 3 16 6 | — |
| No. 3 Foundry, ditto | 3 14 0 | — |
| Basic, d/d (*Less 5/– rebate*) | 3 10 0 | — |
| N.W. COAST— | 3 14 0 d/d Glasgow | |
| Hematite Mixed Nos. | 3 18 6 „ Sheffield | |
| | 4 4 6 „ Birmingham | |

## MANUFACTURED IRON.

| | Home. | Export. |
|---|---|---|
| LANCS.— | £ s. d. | £ s. d. |
| Crown Bars | 9 12 6 | — |
| Best Bars | 10 2 6 | — |
| S. YORKS.— | | |
| Crown Bars | 9 12 6 | — |
| Best Bars | 10 2 6 | — |
| MIDLANDS— | | |
| Crown Bars | 9 15 0 | — |
| Marked Bars (Staffs.) | 12 0 0 | — |
| No. 3 quality | 7 17 6 | — |
| No. 4 „ | 8 10 0 | — |
| SCOTLAND— | | |
| Crown Bars | 9 12 6 | 9 5 0 |
| Best | 10 2 6 | 9 15 0 |
| N.E. COAST— | | |
| Common Bars | 9 12 6 | 8 15 0 |
| Best Bars | 10 2 6 | 9 15 0 |
| Double Best Bars | 10 12 6 | 10 0 0 |

## STEEL.

| LONDON AND THE SOUTH— | Home. £ s. d. | Export. £ s. d. |
|---|---|---|
| Angles | 8 10 0 | 7 10 0 |
| Tees | 9 10 0 | 8 10 0 |
| Joists | 8 17 6 | 7 10 0 |
| Channels | 8 15 6 | 7 15 0 |
| Rounds, 3in. and up | 9 10 0 | 8 10 0 |
| „ under 3in. | 8 14 6 | 7 0 0 |
| Flats, 5in. and under | 8 14 6 | 7 0 0 |
| Plates, ¼in. (basis) | 9 0 0 | 7 15 0 |
| „ 5/16in. | 9 5 0 | 8 0 0 |
| „ ⅜in. | 9 10 0 | 8 5 0 |
| „ 7/16in. | 9 15 0 | 8 10 0 |
| „ ½in. | 9 10 0 | 8 5 0 |
| NORTH-EAST COAST— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Plates, ¼in. | 8 15 0 | 7 15 0 |
| „ 5/16in. | 9 0 0 | 8 0 0 |
| „ ⅜in. | 9 5 0 | 8 5 0 |
| „ 7/16in. | 9 10 0 | 8 10 0 |
| „ ½in. | 9 5 0 | 8 5 0 |
| Boiler Plates, ¼in. | 9 5 0 | — |
| MIDLANDS, AND LEEDS AND DISTRICT— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Flats, 5in. and under | 8 12 0 | 8 17 6 |
| Plates, ¼in. (basis) | 8 17 6 | 7 15 0 |
| „ 5/16in. | 9 2 6 | 8 0 0 |
| „ ⅜in. | 9 7 6 | 8 5 0 |
| „ 7/16in. | 9 12 6 | 8 10 0 |
| „ ½in. | 9 5 0 | 8 5 0 |
| Boiler Plates, ¼in. | 9 7 6 | 7 15 0 |

## STEEL (*continued*).

| GLASGOW AND DISTRICT— | Home. £ s. d. | Export. £ s. d. |
|---|---|---|
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Flats, 5in. and under | 8 12 0 | 8 17 6 |
| Plates, ¼in. (basis) | 8 15 0 | 7 15 0 |
| „ 5/16in. | 9 0 0 | 8 0 0 |
| „ ⅜in. | 9 5 0 | 8 5 0 |
| „ 7/16in. | 9 10 0 | 8 10 0 |
| „ ½in. | 9 5 0 | 8 5 0 |
| Boiler plates | 9 5 0 | — |
| SOUTH WALES AREA— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Flats, 5in. and under | 8 12 0 | 8 17 6 |
| Plates, ¼in. (basis) | 8 17 6 | 7 15 0 |
| „ 5/16in. | 9 2 6 | 8 0 0 |
| „ ⅜in. | 9 7 6 | 8 5 0 |
| „ 7/16in. | 9 12 6 | 8 10 0 |
| „ ½in. | 9 10 0 | 8 5 0 |

| IRELAND— | Belfast. £ s. d. | Rest of Ireland. £ s. d. |
|---|---|---|
| Angles | 8 12 6 | 8 15 0 |
| Tees | 9 12 6 | 9 15 0 |
| Joists | 9 0 0 | 9 2 6 |
| Channels | 8 17 6 | 9 0 0 |
| Rounds, 3in. and up | 9 12 6 | 9 15 0 |
| „ under 3in. | 9 2 0 | 9 4 6 |
| Plates, ¼in. (basis) | 9 0 0 | 9 2 6 |
| „ 5/16in. | 9 5 0 | 9 7 6 |
| „ ⅜in. | 9 10 0 | 9 12 6 |
| „ 7/16in. | 9 15 0 | 9 17 6 |
| „ ½in. | 9 12 6 | 9 15 0 |

### OTHER STEEL MATERIALS.

| Sheets. | Home. £ s. d. | Export. £ s. d. |
|---|---|---|
| 10-G. to 13-G., f.o.r. | 9 15 0 | 9 0 0 |
| 14-G. to 20-G., d/d | 11 0 0 | 9 5 0 |
| 21-G. to 24-G., d/d | 11 5 0 | 9 10 0 |
| 25-G. to 27-G., d/d | 11 17 6 | 10 2 6 |

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

| Home. | £ s. d. |
|---|---|
| 4-ton lots and up | 13 5 0 |
| 2-ton to 4-ton lots | 13 12 6 |
| Under 2 tons | 15 5 0 |

*Export:* £12 15s. 0d., c.i.f. India.
„ £11 10s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18s. 9d.
Tin-plate Bars, d/d South Wales Works, £5 10s. 0d.

| Billets. | £ s. d. |
|---|---|
| Basic (0·33% to 0·41% C.) | 6 12 6 |
| „ Medium (0·42% to 0·60% C.) | 7 2 6 |
| „ Hard (0·61% to 0·85% C.) | 7 12 6 |
| „ „ (0·86% to 0·99% C.) | 8 2 6 |
| „ „ (1% C. and up) | 8 12 6 |
| Soft (up to 0·25% C.), 500 tons and up | 5 10 0 |
| 100 to 250 tons | 5 17 6 |
| Rails, Heavy, 500-ton lots, f.o.t. | 8 10 0 |
| „ Light, f.o.t. | 7 10 0 |

## FERRO ALLOYS.

| | Per Ton. | Per Unit. |
|---|---|---|
| Tungsten Metal Powder | 3/3 per lb. | |
| Ferro Tungsten | 3/– per lb. | |
| Ferro Chrome, 4 p.c. to 6 p.c. carbon | £21 15 0 | 7/– |
| „ „ 6 p.c. to 8 p.c. | £21 0 0 | 7/– |
| „ „ 8 p.c. to 10 p.c. | £21 0 0 | 7/– |
| „ „ Specially Refined | | |
| „ „ Max. 2 p.c. carbon | £33 10 0 | 11/– |
| „ „ „ 1 p.c. carbon | £36 5 0 | 11/– |
| „ „ „ 0·50 p.c. carbon | £37 5 0 | 12/– |
| „ „ „ carbon free | 9½ per lb. | |
| Metallic Chromium | 2/5 per lb. | |
| Ferro Manganese (loose), 76 p.c. | £10 15 0 home | |
| „ Silicon, 45 p.c. to 50 p.c. | £12 15 0 scale 5/– p.u. | |
| „ „ 75 p.c. | £17 17 6 scale 6/– p.u. | |
| „ Vanadium | 12/8 per lb. | |
| „ Molybdenum | 4/6 per lb. | |
| „ Titanium (carbon free) | 9d. per lb. | |
| Nickel (per ton) | £200 to £205 | |
| Cobalt | 5/6 per lb. | |

## NON-FERROUS METALS.

*Official Prices, December 4th.*

| | | |
|---|---|---|
| COPPER— | | |
| Cash | £35 11 3 to £35 12 6 | |
| Three months | £36 0 0 to £36 1 3 | |
| Electrolytic | £39 15 0 to £40 5 0 | |
| Best Selected Ingots, d/d Birmingham | £39 15 0 | |
| Sheets, Hot Rolled | £66 0 0 | |
| | Home. | Export. |
| Tubes, Solid Drawn (basis) | 10½d. | 10½d. |
| „ Brazed (basis) | 10½d. | 10½d. |
| BRASS— | | |
| Ingots, 70/30, d/d Birmingham | £32 0 0 to £33 0 0 | |
| | Home. | Export. |
| Tubes, Solid Drawn, 2/1 Alloy | 9¾d. | 9¾d. |
| „ Brazed | 11¾d. | 11¾d. |
| TIN— | | |
| Cash | £224 5 0 to £224 15 0 | |
| Three months | £213 10 0 to £213 15 0 | |
| LEAD: Cash and forward | £17 15 0 | |
| SPELTER: | £15 15 0 to £16 1 3 | |
| Aluminium Ingots (British) | £100 | |

## FUELS.

### SCOTLAND.

| LANARKSHIRE— | Export. |
|---|---|
| (f.o.b. Grangemouth)—Navigation Unscreened | 14/– to 14/6 |
| Hamilton Ell | 16/6 to 17/– |
| Navigation Splints | 18/– to 18/6 |
| AYRSHIRE— | |
| (f.o.b. Ports)—Steam | 14/6 to 15/– |
| FIFESHIRE— | |
| (f.o.b. Methil or Burntisland)— | |
| Prime Steam | 15/6 |
| Unscreened Navigation | 14/– to 14/6 |
| LOTHIANS— | |
| (f.o.b. Leith)—Hartley Prime | 16/– to 16/6 |
| Secondary Steam | 15/6 to 16/– |

### ENGLAND.

| YORKSHIRE, MANCHESTER— | |
|---|---|
| B.S.Y. Hard Steams | 18/6 to 21/6 |
| Furnace Coke | 14/6 to 17/6 |
| NORTHUMBERLAND, NEWCASTLE— | |
| Blyth Best | 15/– to 15/6 |
| „ Second | 14/– to 14/6 |
| „ Best Small | 10/6 to 11/– |
| Unscreened | 12/6 to 13/6 |
| DURHAM— | |
| Best Gas | 14/8 |
| Foundry Coke | 19/– to 20/– |

| SHEFFIELD— | Inland. |
|---|---|
| Best Hand-picked Branch | 24/– to 26/– |
| South Yorkshire Best | 21/– to 23/– |
| South Yorkshire Seconds | 18/– to 19/– |
| Rough Slacks | 9/– to 10/– |
| Nutty Slacks | 8/– to 9/– |

### SOUTH WALES.

| CARDIFF— | |
|---|---|
| Steam Coals: | |
| Best Admiralty Large | 19/6 |
| Best Seconds | 19/– to 19/4½ |
| Best Dry Large | 18/9 to 19/3 |
| Ordinaries | 18/3 to 18/6 |
| Bunker Smalls | 12/6 to 13/6 |
| Cargo Smalls | 11/6 to 12/6 |
| Dry Nuts | 22/– to 27/6 |
| Foundry Coke | 27/– to 40/– |
| Furnace Coke | 19/– to 22/6 |
| Patent Fuel | 21/– |
| SWANSEA— | |
| Anthracite Coals: | |
| Best Large | 36/– to 40/– |
| Machine-made Cobbles | 41/– to 48/6 |
| Nuts | 40/– to 48/6 |
| Beans | 25/– to 30/– |
| Peas | 19/– to 23/– |
| Rubbly Culm | 11/– to 11/6 |
| Steam Coals: | |
| Large Ordinary | 18/– to 20/6 |

## FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

| Ex Ocean Installation. | Per Gallon. |
|---|---|
| Furnace Oil (0·950 gravity) | 3½d. |
| Diesel Oil | 4d. |

# French Engineering Notes.

*(From our own Correspondent in Paris.)*

### Industrial Difficulties.

AT a time when Great Britain and the United States are said to be "out of the crisis" and improvements are reported in other countries, French manufacturers are asking when it will be their turn to be carried forward by the tide. There are plenty of elements of activity which would favour a revival if they were not counteracted by financial and other difficulties that accumulate and leave industry in an apparently hopeless situation. With money holding aloof from all industrial enterprise there is little demand for structural material, except that required for national public works, and the sales of machinery have rarely been so disappointing as they are now. The steady increase of official unemployment figures is, of itself, evidence of an unsatisfactory state of affairs, and there is a continued exodus of foreign workers who, if they remained in the country, would nearly double the weekly unemployment returns. Being only concerned in opportunities for improving trade, the industrial and commercial classes are naturally aggrieved at any loss resulting from the application of sanctions, particularly by the fear that some of that loss may never be recovered, and there is an organised and general movement to obtain from the State an assurance that such losses shall be made good. In fact, it is not improbable that international solidarity over the question of sanctions may facilitate a similar solidarity in international trade and prepare the way for a revival of business in this country.

### Railway Works.

The total amount of 1321 million francs approved by the Superior Railway Council for expenditure on rolling stock, signalling, electrification, and other work in the coming year shows an all-round reduction on the previous figure. The cut is in accordance with the national economy plan and is particularly intended to avoid an increasing deficit in the railway companies' "common fund," but the work provided for is exclusive of that being carried out under the public relief works programme, which has enabled the companies to put in hand a general scheme for improving the efficiency and safety of railways. Meanwhile, the expenditure of 409 million francs on rolling stock does not satisfy locomotive and wagon builders, who expected more for renewals. Provision is made for the maintenance of existing locomotives and a reorganisation of services, so that locomotives will cover greater annual mileages, and coaches will be rebuilt with metallic bodies. The new stock comprises six steam locomotives, four electric locomotives, twenty-two oil-engined locomotives, 170 railcars, 260 main line coaches, 140 suburban coaches, and 175 vans. The coaches and vans will be of metallic construction. Four of the steam locomotives will be experimental types for the Compagnie du Nord, two of them triple expansion and one with an American type of grate. The railcars are intended to run on local lines that have not been suppressed by the new road and rail traffic organisation. There are several different types of railcars for purposes of comparison, and no attempt can yet be made to standardise them. Work is to be started upon the electrification of the Paris-Le Mans line, and there will be a further extension of electrification on the Paris suburban railways.

### Light Engineering.

A cause of stability in the lighter branches of the mechanical engineering industry is probably the effect of decentralisation produced by a distribution of work amongst a considerable number of small shops, run by mechanics and technicians with long experience in works and factories who prefer to launch out on their own account in such works, which are sometimes rented with plant and machinery. They profit from advantages offered by artisan legislation that relieves small master craftsmen of taxes and charges that weigh heavily on the engineering industries. Having practically no overhead charges, and producing at low cost, they are useful collaborators of big manufacturers, who distribute amongst them work that cannot be conveniently dealt with by their own specialised equipment, and competition for the business offers further inducement to utilise the services of these outside workshops. There is a growing tendency amongst small firms to distribute all the work for special light machines and tools, and content themselves with supplying the material, exercising strict control over the reception of machined parts and assembling them, so that the firms reduce their own overhead charges to a minimum and know exactly what the machines will cost them, while the small capital required is an important consideration during the present long period of dear money. Moreover, the competition of outside master mechanics allows of a certain margin in adjusting costs to competitive selling. In the case of engineering tools, in which parts subjected to severe stresses are usually made of forged mild steel, it has been possible to employ, for the sake of lightness, heat-treated, high-resistance steel without increase of selling price.

### Franco-British Trade.

An analysis of the foreign trade returns during the first ten months of the year shows that while imports into this country from Great Britain amounted to 1296 million francs, and from the rest of the British Empire to 1176 millions, the exports from France to Great Britain totalled 1290 million francs and to the remainder of the Empire 191 millions. Compared with the similar period of 1934, the total imports from the British Empire increased by 30 millions, and the exports thereto declined by 13 millions, notwithstanding an increase of 34 million francs to Great Britain. A curious feature of the returns is that while imports from the Irish Free State fell from 4,901,000f. to 2,856,000f., the exports of French goods to that country augmented from 17 million francs to 19 millions. Canada and British India alone appreciably increased their exports to France.

# British Patent Specifications.

*When an invention is communicated from abroad the name and address of the communicator are printed in italics.*

*When an abridgment is not illustrated the Specification is without drawings.*

*Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.*

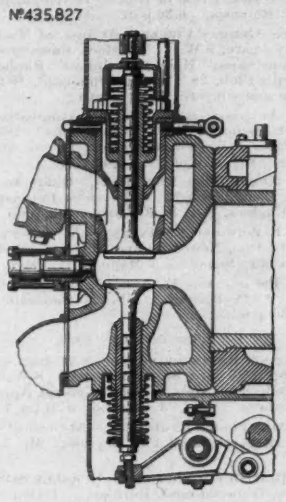
*The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.*

## INTERNAL COMBUSTION ENGINES.

435,827. June 25th, 1934.—HORIZONTAL DIESEL ENGINES, The Brush Electrical Engineering Company, Ltd., Falcon Works, Loughborough, and G. Senior.

This invention resolves itself into a reversal of the usual arrangement of valves for a horizontal oil engine. The exhaust

Nº435,827

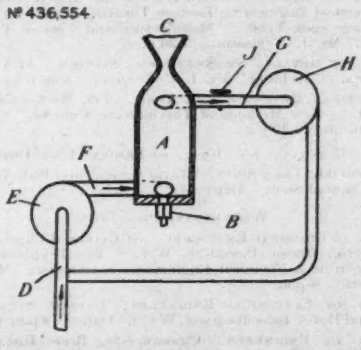


valve is put above and the inlet valve below the fuel injection jet. The reason is that dribbles of oil from the jet then fall on to the cool inlet valve, instead of on to the hot exhaust valve, and decarbonisation is consequently minimised. Incidentally the cooling of the inlet valve is improved and access to the exhaust valve facilitated.—*September 30th*, 1935.

436,554. June 7th, 1934.—RECIPROCATING OR TURBINE INTERNAL COMBUSTION ENGINES, E. C. Saint-Jaques, 11, Rue Marbeau, Paris, France.

This is a scheme for producing a flow of gas from the combustion of fuel for driving a gas engine or turbine. Combustion takes place in the chamber A and is initiated by the sparking plug B. The products of combustion are delivered to the engine through the outlet C. The combustible mixture is drawn in at D and forced by the blower E into the chamber by a tangential passage F. At the upper end of the chamber there is a connec-

Nº 436,554.



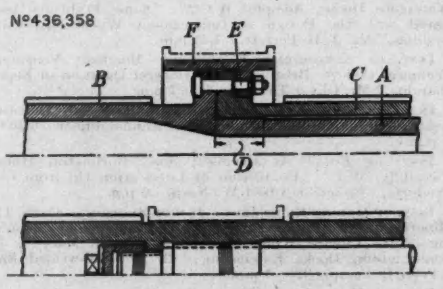

tion G with another blower H, which sucks the contents out and returns them to the inlet. In this connection G there is a valve J. The process of operation is as follows:—The combustible mixture is circulated through the chamber by the two blowers until it attains a high velocity. The valve J is then suddenly shut. The check in the flow of the gas raises its pressure and it is ignited by the sparking plug. The products of combustion go out through the outlet C and do not, it is said, blow back into the blower on account of the tangential direction of the inlet F. The cycle is then repeated.—*October 14th*, 1935.

## TRANSMISSION OF POWER.

436,358. April 18th, 1935.—PINIONS WITH DIVIDED TEETH, G. Bauer, Mittelweg 82, Hamburg, Germany.

This is an arrangement of pinions which must have a great length of tooth to transmit the power, and is said to provide a shorter assembly than usual. The driving shaft is shown at A,

Nº436,358

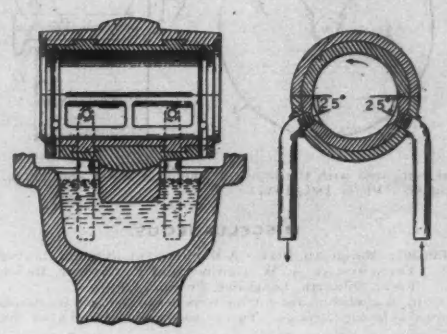



and on its end there is cut a set of teeth B. Another set of teeth is cut on the sleeve C, which is shrunk on at D and held by the flange bolts E. Otherwise, it is free of the shaft. The flanges also carry a collar F which acts as a bearing journal.—*October 9th*, 1935.

435,835. November 14th, 1934.—HORIZONTAL SUCTION BEARINGS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

This bearing is said to be suitable for shafts up to a diameter of about 10in., and for those which run either too fast or too slowly for ring lubrication. It is a simple shell bearing, but at "about point of lowest sub-atmospheric operating pressure,

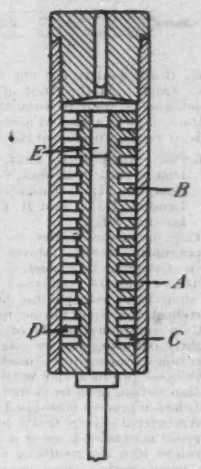
Nº435,835




which may be defined as approximately 65 angular degrees from the line of maximum load, in the leading direction having regard to the direction of rotation of the shaft," there is cut an axial groove, which is connected with the oil well by a pipe. On the opposite side of the bearing there is another groove and pipe, which return part of the oil carried over the bearing back to the well.—*September 30th*, 1935.

## MEASURING AND TESTING INSTRUMENTS.

Nº436,836




436,836. February 16th, 1935.—THERMOSTATS, G. G. Royer, 31, Boulevard Péreire, Paris, France.

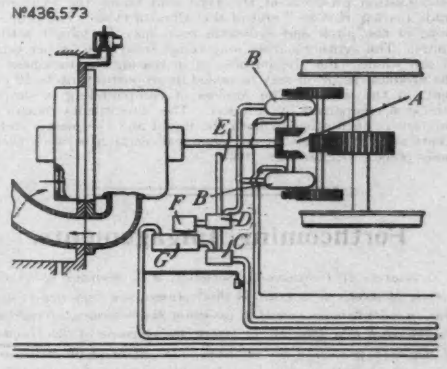
This thermostat depends for its action on the expansion of fatty materials, such as ceryl-alcohol, which have a high degree of expansion, but are poor conductors of heat. The material is consequently held in a container having a very large heat-radiating surface. It is formed as a tube A and a tightly fitting plug B. The plug has grooves C for the reception of the fatty material, which communicate with one another by the passages D. The expansion of the material acts on the central piston E, which may be used to operate any regulating apparatus.—*October 18th*, 1935.

## LOCOMOTIVES.

436,573. March 12th, 1934.—STEAM TURBINE LOCOMOTIVES, A. Reidanger, 5, Hurst-road, Winchmore-hill, London, N.21.

In this locomotive a single turbine is used for going ahead or reversing. Reversal is effected by the double-bevel drive A.

Nº436,573



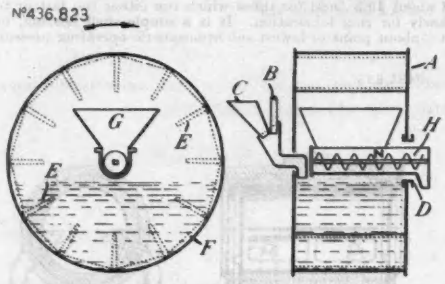

Either drive is put into operation by the "fluid fly-wheels" B B, and drives the axle by the gearing shown. The oil for the fluid fly-wheels is supplied by the pump C, while D is an extraction pump. Both these pumps are driven off a transverse shaft E. F is an oil cooler and G a sump.—*October 14th*, 1935.

## WATER PURIFICATION.

436,823. October 3rd, 1934.—DEWATERING SLURRY, H. J. Greaves, 1, Gordon-rise, Nottingham.

This is a machine for dewatering the slurry from coal-washing plants. The slurry is introduced into the slowly rotating drum A by the spout B, and is mixed with a certain proportion of slack from the shoot C. Surplus water overflows at D. The interior of the drum is divided by a number of partitions E E, which are formed of filtering material, while the periphery also has a filtering lining F. The spaces behind these filter cloths are connected with a suction pump. The dewatered solids fall from the filtering surfaces into the hopper G and are taken away by the conveyor H. According to the inventor the process may be more fully demonstrated by assuming that in a unit of time there is delivered into the drum an input of 900 lb. of liquor composed of 600 lb. of water and 300 lb. of recoverable solids, and that there is sucked out through the filtering surfaces 300 lb. of clarified water leaving on the filtering surfaces due to such applied suction a deposit of 100 lb. of solids and that, in addition, during the unit of time, there is deposited on the filtering surfaces by reason of gravitation settlement a further 150 lb. of solids (all of which solids are removed from the

drum), leaving a balance of liquor to pass out of the drum through the overflow, and which is composed of 300 lb. of water and 50 lb. of solids—that is, in a partially clarified condition

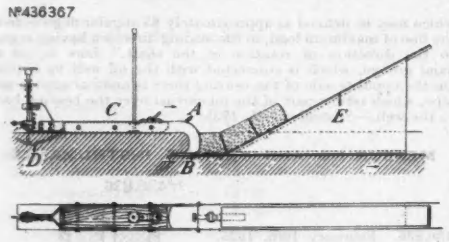



as compared with the input of 600 lb. of water and 300 lb. of solids.—*October 18th*, 1935.

## MISCELLANEOUS.

436,367. March 7th, 1934.—A MACHINE FOR CUTTING DRAINING TRENCHES, G. A. W. Gardner and F. Gardner, Radcliffe Farm, Dilworth, Longridge, Preston, Lancs.

This is a machine for cutting trenches in the land for drainage or cable-laying purposes. Two vertical knives A and a horizontal




knife B are used to cut out the trench, and are attached to a draw-bar C. At the front of this draw-bar there is a shoe D, which can be used to vary the depth of the cut. Behind the cutters there is attached a ramp E up which the clods of earth slide, to be drawn aside at the top with a rake.—*October 7th*, 1935.

436,876. April 19th, 1934.—A MATERIAL FOR ELECTRICAL INSULATING PURPOSES, Callender's Cable and Construction Company, Ltd., Hamilton House, Victoria Embankment, London, E.C.4, and H. Cox, 71, Wickham-road, Brockley, London, S.E.4.

This invention relates to insulating material produced by impregnating textile fabrics or other fibrous material in the form of sheet or tape, such as cotton, linen, silk, wool, or paper. It is particularly concerned with the production of material in strip form suitable for lapping on an electric conductor. The sheet or strip of fibrous material is impregnated and coated with a compound made of a mixture of a non-oxidising or slightly oxidising stearin pitch with a suitable synthetic resin. The non-oxidising pitch used in the present case is a recently developed product and is obtained from North American or Indian cotton seed by a method of manufacture in which the distillation process is stopped at a definite point. If the distillation is carried beyond this point a pitch unsuitable for the present purpose is obtained, since it has too high a melting point and develops into the oxidising type of pitch which is unsuitable for impregnating sheet material required to have adhesive properties. The synthetic resin employed must be substantially insoluble in mineral oil, but soluble in fatty oils of the castor oil type. A synthetic resin which dissolves in such oils is also soluble in the pitch with which the invention is concerned. The synthetic resin must also be non-heat-hardening and free from acidity. Suitable resins are, for example, those made from phthalic anhydride with glycerol and oleic acid, those made from treated phenol-formaldehyde or cresol-formaldehyde condensation products of the type sold under the registered trade mark "Homac" and of the Albertol type. The proportions of the pitch and synthetic resin may be varied within limits. The synthetic resin may range from 1 to 76 per cent. of the whole. For the purpose of increasing the tackiness of the product castor oil may be added in proportions up to 20 per cent. of the whole. The process of compounding is simply mixing accompanied by solution. The constituents remain in solution in each other in both the liquid and the plastic state. There is no evidence that any chemical reaction between them takes place.—*October 21st*, 1935.

## Forthcoming Engagements.

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### TO-DAY.

INST. OF ELECTRICAL ENGINEERS: N. EASTERN STUDENTS.—Armstrong College, Newcastle-upon-Tyne. "Electricity Supply Legislation," Mr. G. V. Harrap. 7.15 p.m.

INST. OF FUEL.—British Industries House, Marble Arch, W.1. Mr. H. A. Humphrey will open discussion, "The Adequacy of Our Fuel Supplies in a Time of National Emergency." 6.30 for 7 p.m.

INST. OF FUEL: E. MIDLAND SECTION.—Joint meeting with Lincoln Engineering Soc. Technical College, Lincoln. "Sources of Fuel Oils," Dr. A. R. Bowen. 7.30 p.m.

INST. OF HEATING AND VENTILATING ENGINEERS.—Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel-street, Gower street, W.C.1. "Some Notes on Humidity," Mr. C. L. Burdick. 7 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, S.W.1. Informal meeting. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH.—Leicester. "Rigid Frame Bridges in Reinforced Concrete," Mr. A. P. Mason. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: WESTERN COUNTIES BRANCH.—Merchant Venturers' Technical College, Bristol. "Some Aspects of the Theory of Corrosion," Mr. W. H. Dearden. 7.15 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting, "Iron: Past and Present, Manufacture and Uses," Mr. R. Lowe. 7.30 p.m.

PHYSICAL SOC.—At Imperial College of Science and Technology, South Kensington, S.W.7. Council meeting, 3.45 p.m.; meeting, 4.30 for 5 p.m.

PHYSICAL SOC.—At Imperial College of Science and Technology, S. Kensington, S.W.7. Thomas Young Oration, "Vision in Optical Instruments," Professor Charles Fabry. 5 p.m.

RAILWAY CLUB.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "How the L.B. and S.C. Railway Kept the Eastbourne Traffic," Rev. R. B. Fellows. 7.30 p.m.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1. Discourse by Mr. F. L. Lucas. 9 p.m.

### SATURDAY, DEC. 7TH.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Engineers' Club, Manchester. "The Dagenham Foundry of the Ford Motor Company," Mr. J. N. Burns and Mr. V. C. Faulkner. 3.45 p.m.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Visit to Bowater's Paper Mills, Ltd., Northfleet. 2.30 p.m.

### MONDAY, DEC. 9TH.

CHARTERED SURVEYORS' INST.—12, Great George-street, S.W.1. "The Restriction of Ribbon Development Act, 1935," Mr. A. T. V. Robinson. 6.30 p.m.

ENGINEERS' GERMAN CIRCLE.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Modern Submerged Pumps and Rotary Compressors," Herr Dipl.-Ing. E. Raphael. 5.15 for 6 p.m. Eliot's Club, 28, Charing Cross-road, W.C.2. German conversation and supper. After meeting.

INST. OF AUTOMOBILE ENGINEERS.—Graduates' meeting at James Watt Memorial Inst., Birmingham. Annual business meeting. Paper, "Review of the Heat Treatments of Steel and Light Alloys," Mr. A. Willetts. 7.45 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Graduates' meeting at the College, Loughborough. "Causes of Detonation in Diesel and Petrol Engines," Mr. P. M. Lane. 7.30 p.m.

INST. OF ELECTRICAL ENGINEERS: N. EASTERN CENTRE.—Armstrong College, Newcastle-upon-Tyne. "Modern Developments in Railway Signalling," Major L. H. Peter. 7 p.m.

INST. OF PRODUCTION ENGINEERS.—College of Technology, Manchester. "Psychology of Works Management," Mr. W. Symes. 7.30 p.m.

### TUESDAY, DEC. 10TH.

ILLUMINATING ENGINEERING SOC.—At Inst. of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Practical Electric Discharge Lamps: Their General Applications and Recent Advances," Mr. L. J. Davies. 6.30 for 7 p.m.

INST. OF AUTOMOBILE ENGINEERS.—At Geisha Café, Hertford-street, Coventry. "Small Car Engines," Mr. L. J. Shorter. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: BURNLEY SECTION.—Municipal College, Ormerod-road, Burnley. "Oxy-acetylene Welding, with More Particular Reference to Cast Iron," Mr. E. B. Partington. 7.15 p.m.

INST. OF ELECTRICAL ENGINEERS: S. MIDLAND STUDENTS.—James Watt Memorial Inst., Birmingham. Students' lecture. "Development in the Materials of Construction of Electrical Plant and Apparatus—Magnetic, Insulating, Conducting, and Mechanical," Mr. A. P. M. Fleming. 7 p.m.

INST. OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—North British Station Hotel, Edinburgh. "A Review of Recent Developments in Rural Electrification," Mr. D. Ross. 7 p.m.

INST. OF MARINE ENGINEERS.—85–88, The Minories, E.C.3. "Marine Machinery Failures—Their Causes and Prevention," Dr. S. F. Dorey. 6 p.m.

INST. OF MECHANICAL ENGINEERS: N.W. BRANCH.—In Lecture Theatre, Central Library, Manchester. Thomas Hawksley Lecture, "Muscles and Nerves, Posture, Power and Communications in the Body," Prof. A. V. Hill. 7.15 p.m.

INST. OF METALS: NORTH-EAST COAST LOCAL SECTION.—In Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-upon-Tyne. "Manufacture and Uses of Powdered Metals," Mr. J. C. Chaston. 7.30 p.m.

INST. OF METALS: SWANSEA LOCAL SECTION.—At Y.M.C.A., Swansea. "Welding," Mr. L. C. Percival. 6.30 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "New Methods of Thermostatic Control," Mr. D. B. Williamson. 7.30 p.m.

### TUESDAY, DEC. 10TH., TO FRIDAY, DEC. 13TH.

SMITHFIELD CLUB SHOW.—Royal Agricultural Hall, Islington, N.1. Annual Show. Daily.

### WEDNESDAY, DEC. 11TH.

INST. OF CHEMICAL ENGINEERS.—At Rooms of Chemical Soc., Burlington House, Piccadilly, W.1. "The Textile Finishing Trades, from a Chemical Engineering Standpoint," Mr. J. E. Howarth. 6 p.m.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Imperial Hotel, Russell-square, W.C.1. Dance. 8 p.m. to 1 a.m.

INST. OF ENGINEERS-IN-CHARGE.—St. Bride Inst., Bride-lane, E.C.4. Three short papers, "Central Heating and Hot Water Supply," by Gas, Electricity, Coal and Coke respectively, Messrs. R. J. Willamer, A. Klansner, and H. F. Philliston. 6.30 for 7.30 p.m.

LIVERPOOL ENGINEERING SOC.—9, The Temple, 24, Dale-street, Liverpool. "Large Turbines for Land Power Stations," Mr. L. S. Robson. 6.30 p.m.

NEWCOMEN SOC.—At Science Museum, S. Kensington, S.W.7. "English Instrument Making in the Eighteenth Century," Dr. R. S. Clay and Mr. T. H. Court. 5.30 p.m.

ROYAL AGRICULTURAL SOC. OF ENGLAND.—Royal Agricultural Hall, Islington, N.1. Annual general meeting. 2.30 p.m.

ROYAL SOC. OF ARTS.—John-street, Adelphi, W.C.2. "The Organisation of Transport, with Special Reference to London Passenger Transport Board," Mr. Frank Pick. 8 p.m.

### THURSDAY, DEC. 12TH.

INST. OF AUTOMOBILE ENGINEERS.—Graduates' meeting, Watergate House, Adelphi, W.C.2. "Some Problems Associated with the Design of Independent Wheel Suspension Systems," Mr. J. B. Perrett. 7.25 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Merchant Venturers' Technical College, Bristol. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7 p.m.

INST. OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOC.—Queen's Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

INST. OF FUEL.—At Chemical Soc., Burlington House, Piccadilly, W.1. "Production of Lubrication Oil from Coal Products," Professor Alfred W. Nash. 6 p.m.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—85–88, The Minories, E.C.3. Film Display: (1) The Building and Launching of the Cunard White Star Liner "Queen Mary"; (2) Southampton Docks Extensions; (3) The All-welded Ship "Peter G. Campbell." 7 p.m.

INST. OF MECHANICAL ENGINEERS: YORKSHIRE BRANCH.—Hotel Metropole, Leeds. Chairman's Address, "The Choice of Steels for Particular Purposes," G. E. Wolstenholme. 7.45 p.m.

INST. OF METALS: LONDON LOCAL SECTION.—Joint meeting with Inst. of British Foundrymen, in Rooms of Soc. of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. "Die Casting of Non-ferrous Alloys," Mr. N. D. G. Robertson. 7.30 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. "Some Bridge and Foundation Problems," Mr. Leslie Turner. 6.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS: TEES-SIDE BRANCH.—At Cleveland Scientific and Technical Inst., Corporation-road, Middlesbrough. "Shipbuilding by Welding," Mr. N. M. Hunter and H. W. Townshend. Film showing construction of ocean-going oil tanker "Moira." 7.30 p.m.

### FRIDAY, DEC. 13TH.

BELFAST ASSOC. OF ENGINEERS.—Queen's Hotel, Belfast. Smoking concert. 8 p.m.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE JUNIOR SECTION.—College of Technology, Manchester. Joint paper by Messrs. H. V. Grundy and A. Phillips. 7.30 p.m.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Savoy-place, W.C.2. "The Students'" Lecture, "Developments in the Materials of Construction of Electrical Plant and Apparatus—Magnetic, Insulating, Conducting, and Mechanical," Mr. A. P. M. Fleming. 6.30 for 7 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Students' meeting, 39, Elmbank-crescent, Glasgow, C.2. "Ship Salving and Breaking with Classification of Metals," Mr. Mackenzie. 8 p.m.

INST. OF FUEL: EAST MIDLAND SECTION.—Joint meeting with Soc. of Chemical Industry. University College, Nottingham. "Compressed Gas as a Fuel for Motor Transport," Mr. R. Cook. 7 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, S.W.1. "Damping Influences in Torsional Oscillation," Dr. J. F. Shannon. 6 p.m.

INST. OF METALS: SHEFFIELD LOCAL SECTION.—In Non-Ferrous Section of Applied Science Dept. of University, St. George's-square, Sheffield. "The Adhesion of Electro-deposited Nickel," Mr. A. W. Hothersall. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—At Royal Soc. of Arts, John-street, W.C.2. Presidential address, "Coal, Power and Smoke," Sir Frank E. Smith. 7.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS.—Mining Inst., Newcastle-upon-Tyne. "Notes on the Development of Tugboat Machinery during the Past Forty-six Years," Mr. G. Baird. 6 p.m.

### FRIDAY AND SATURDAY, DEC. 13TH AND 14TH.

BOROUGH POLYTECHNIC.—Borough-road, S.E.1. Exhibition of Students' Work. Friday, 6 to 9 p.m.; Saturday, 4 to 9.30 p.m.

### SATURDAY, DEC. 14TH.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—85–88, The Minories, E.C.3. Dance. 7.30 to 11.15 p.m.

MANCHESTER ASSOC. OF ENGINEERS.—At College of Technology, Manchester. Conversazione and dance. 6.45 p.m. to 11.30 p.m.

### MONDAY, DEC. 16TH.

INST. OF AUTOMOBILE ENGINEERS.—At James Watt Memorial Inst., Birmingham. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. "Small Car Engines," Mr. L. J. Shorter. 7.45 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, S.W.1. Graduates' Meeting. "Oil," Mr. R. A. Robbins. 6.45 p.m.

INST. OF METALS: SCOTTISH LOCAL SECTION.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. "Addition of Non-ferrous Metals to Cast Iron," Mr. J. E. Hurst. 7.30 p.m.

### TUESDAY, DEC. 17TH.

ANNUAL CHEMICAL DINNER.—Wharncliffe Rooms, Great Central Hotel, Marylebone, N.W.1. Dinner, 7.30 p.m.; dancing, 9.30 to midnight. Tickets may be obtained from Mr. F. A. Greene, The Chemical Club, 2, Whitehall-court, S.W.1.

ILLUMINATING ENGINEERING SOC.—Joint meeting with Royal Photographic Soc., 35, Russell-square, London, W.C.1. "Photographic Representation of Street Lighting Installations," Mr. R. G. Hopkinson. 6.30 for 7 p.m.

INST. OF AUTOMOBILE ENGINEERS.—The Cavendish Café, Cornmarket, Derby. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Coventry Graduates' meeting, at Broadgate Café, Coventry. "Electrical Speed Indicating Equipment," Mr. G. A. Freeman. 7.15 p.m.

INST. OF AUTOMOBILE ENGINEERS.—The George Hotel, Luton. "Inspection and Quality Control," Mr. M. C. Park. 7.30 p.m.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND STUDENTS.—Hotel Metropole, Leeds. "Pollution of Suspension Type Insulators on Overhead Lines," Mr. K. C. Coop. 7.15 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. "Diesel-electric Paddle Boat 'Talisman,'" Mr. G. A. Inglis. 7.30 p.m.

INST. OF METALS.—James Watt Memorial Inst., Birmingham. "Recent Developments in Refractories," Mr. C. E. Moore. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: SCOTTISH BRANCH.—University Old College, Edinburgh. "Bridges," Mr. J. Shannon. 7.15 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "Oxygen in Steel," Dr. L. Reeve. 7.30 p.m.

### WEDNESDAY, DEC. 18TH.

CRYSTAL PALACE SCHOOL OF PRACTICAL ENGINEERING.—189th Award of Certificates by Mr. Cecil Molesworth Bunbury. 3 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Birmingham Graduates' visit to Colmore Repair Works, Cherrywood-road, Bordesley Green. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Engineers' Club, Manchester. "Rotary Valves," Mr. R. C. Cross. 7 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Hotel Metropole, Leeds. "Inspection and Quality Control," Mr. M. C. Park. 7.15 p.m.

### THURSDAY, DEC. 19TH.

INST. OF AUTOMOBILE ENGINEERS.—Bristol Graduates' meeting at Merchant Venturers' Technical College, Bristol. Paper by Mr. C. E. Squire. 7.30 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. "Design and Construction of an All-welded Multiple-storey Steel Structure," Mr. R. W. MacBride. 6.30 p.m.

### FRIDAY, DEC. 20TH.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting, "Film on Fabrication and Application of Hewittic Rectifiers." 7.30 p.m.

INST. OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH.—James Watt Memorial Inst., Birmingham. "Some Recent Experiences of Structural Engineering in the United States of America," Mr. H. C. Rowan. 6.30 p.m.